COMMUNITY MANAGED RURAL WATER SUPPLY SYSTEMS IN THE DOMINICAN REPUBLIC:

Assessment of Sustainability of Systems Built by the National Institute of Potable Water and Peace Corps, Dominican Republic

By

Ryan W. Schweitzer

A Thesis

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This thesis, "Community Managed Rural Water Supply Systems in the Dominican Republic: Assessment of Sustainability of Systems Built by the National Institute of Potable Water and Peace Corps, Dominican Republic" is hereby approved in partial fulfillment of the requirements for the Degree of:

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Signatures:

Thesis Advisor______________________________
James R. Mihelcic

Department Chair___________________________
William Bulleit

Date_______________________

"Water is fundamental for life and health. The human right to water is indispensable for leading a healthy life and human dignity. It is a prerequisite to the realization of all other human rights."

-The United Nations Committee for Economic, Cultural and Social Rights

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Acronyms

AECI	*Agencia Española para Cooperación Internacional* (Spanish Agency for International Cooperation)
ASOCAR	Water Committee (also known as rural water community associations
CAASD	*Corporación del Acueducto y Alcantarillado de Santo Domingo* (Santo Domingo Water and Sewer Corporation)
CIA	Central Intelligence Agency
CM	community management
CORAA	*Corporación del Acueducto y Alcantarillado* (Water and Sewer Corporation)
DO	development organization
DIFD	Department for International Development
DR	Dominican Republic
DRA	demand responsive approach
EHP	Environmental Health Project
ENACAL	*Empresa Nicaragüense de Acueductos y Alcantarillados* (National Water Supply and Sanitation Company, Nicaragua)
ENDESA	*Encuesta Demográfica de Salud* (Health Demographic Survey)
ENHOGAR	*Encuesta Nacional de Hogares de Propósitos Múltiples* (National Multipurpose House Survey)
HDI	human development index
HE	Healthy Environments (Peace Corps water sector)
IDB	Inter-American Development Bank
INAPA	*Instituto Nacional de Aguas Potables y Alcantarillados* (National Water Supply and Sewage Institute)
INAPA-AR	National Water Supply and Sewage Institute Department of Rural Aqueducts
INDRHI	*Instituto Dominicano de Recursos Hidricas (*Dominican Institute of Water Resources)
ISM	institutional support mechanism
MDG	Millennium Development Goals
NGO	non-governmental organization
OECD	Organization for Economic Co-operation and Development
OED	Operations Evaluation Department (a department within the World Bank)
O&M	operations and maintenance

ONAPLAN	*Oficina Nacional de Planificación* (National Planning Office)
ONE	*Oficina Nacional de Estadisticas* (Nation Statistics Office)
PACA	Participatory Analysis for Community Action
PAHO	Pan-American Health Organization
PC	Peace Corps
PCDR	Peace Corps Dominican Republic
PCV	Peace Corps Volunteer
PCS	post construction support
PLANAR	*Plan Nacional de Aquductos Rurales* (Nation Rural Aqueducts Plan)
PVO	private volunteer organization
REO	Regional Ecosystem Office
RWS	Rural Water Supply
SESPAS	Secretariat of Public Health and Social Assistance
SEMARN	Secretary of the Environment and Natural Resources
SNAR	*Servicio Nacional de Aqueductos Rurales* (National Rural Water Systems Service)
TCP	total community participation
UNICEF	United Nations Children's Fund
UNOM	*Unidad de Operación y Mantenimiento* (Operation and Maintenance Unit
WaterAid	A UK based NGO
WB	World Bank
WEDC	Water, Engineering and Development Centre (UK)
WHO	World Health Organization
VLOM	Village Level Operation and Maintenance

Abstract

In the Dominican Republic economic growth in the past twenty years has not yielded sufficient improvement in access to drinking water services, especially in rural areas where 1.5 million people do not have access to an improved water source (WHO, 2006). Worldwide, strategic development planning in the rural water sector has focused on participatory processes and the use of demand filters to ensure that service levels match community commitment to post-project operation and maintenance. However studies have concluded that an alarmingly high percentage of drinking water systems (20-50%) do not provide service at the design levels and/or fail altogether (up to 90%): BNWP (2009), Annis (2006), and Reents (2003).

World Bank, USAID, NGOs, and private consultants have invested significant resources in an effort to determine what components make up an "enabling environment" for sustainable community management of rural water systems (RWS). Research has identified an array of critical factors, internal and external to the community, which affect long term sustainability of water services. Different frameworks have been proposed in order to better understand the linkages between individual factors and sustainability of service.

This research proposes a Sustainability Analysis Tool to evaluate the sustainability of RWS, adapted from previous relevant work in the field to reflect the realities in the Dominican Republic. It can be used as a diagnostic tool for government entities and development organizations to characterize the needs of specific communities and identify weaknesses in existing training regimes or support mechanisms. The framework utilizes eight indicators in three categories (Organization/Management, Financial Administration, and Technical Service). Nineteen independent variables are measured resulting in a score of sustainability likely (SL), possible (SP), or unlikely (SU) for each of the eight indicators. Thresholds are based upon benchmarks from the DR and around the world, primary data collected during the research, and the author's 32 months of field experience. A final sustainability score is calculated using weighting factors for each indicator, derived from Lockwood (2003).

The framework was tested using a statistically representative geographically stratified random sample of 61 water systems built in the DR by initiatives of the National Institute of Potable Water (INAPA) and Peace Corps. The results concluded that 23% of sample systems are likely to be sustainable in the long term, 59% are possibly sustainable, and for 18% it is unlikely that the community will be able to overcome any significant challenge. Communities that were scored as unlikely sustainable perform poorly in participation, financial durability, and governance while the highest scores were for system function and repair service.

The Sustainability Analysis Tool results are verified by INAPA and PC reports, evaluations, and database information, as well as, field observations and primary data collected during the surveys. Future research will analyze the nature and magnitude of relationships between key factors and the sustainability score defined by the tool. Factors include: gender participation, legal status of water committees, plumber/operator remuneration, demand responsiveness, post construction support methodologies, and project design criteria.

1 Introduction

In 2008 it was estimated that 884 million people worldwide were living without access to safe water and 2.5 billion people lacked adequate sanitation (UNICEF, 2008). Water has been implicated in 80% of all sickness and disease worldwide through inadequate sanitation, polluted water, or unavailability of water (WHO, 2007), and at any given moment it has been estimated that half the world's hospital beds are occupied with patients suffering from water-related diseases (UNDP, 2006). To agree with the quote on the previous page from the United Nations Committee for Economic, Cultural and Social Rights and accept the cited statistics should motivate two moral questions: 1) Can I/you/we allow this to continue? And also 2) What can I do to change the current situation? These questions were the starting point and motivators for the following research.

The interconnectedness of water, sanitation, and hygiene education and their collective importance with respect to the Millennium Development Goals in poverty, health, and education is well demonstrated (Mathew, 2005). Water is a necessary but not a sufficient condition to achieve health improvements. It has been shown that potable water or sanitation interventions alone do not influence public health as much as interventions with reinforcing strategies: hygiene education, health and nutrition services, etc. (Esrey, 1990). This thesis' emphasis on water does not attempt to minimize the important and synergistic role in development and public health played by proper sanitation and hygiene education along with other interventions and reinforcing strategies. However, non-governmental organizations and others often see water supply projects as the entry point into building up capacity and empowering the community (Lockwood, 2004). Therefore, in most cases improving a community's capacity to manage water services will also improve capacities to manage or administer other development benefits and services.

1.1 Research Objective

Previous work has suggested that rural water systems (RWS) have low sustainability. Between 20-50% of all systems worldwide do not perform as designed (BNWP, 2009). Specific to our research group, investigations in Madagascar and Honduras have shown that a large majority (over 90% in some cases) can fail due to inadequate financial management schemes (Annis, 2006) or lack of routine repairs (Reents, 2003). Accordingly, this research seeks to:

1. Establish a **Sustainability Analysis Tool**, building upon previous relevant work in the field, which can be used to assess the sustainability of community managed water supply systems in rural areas of the Dominican Republic.
2. Conduct a sustainability analysis of a representative sample of rural water systems in the Dominican Republic that will serve as an **example and framework** to allow practitioners to evaluate training programs as well as post-project support roles to ensure optimal sustainability.

1.2 Sustainability

The word "sustainability" has gained significant ground in the media, politics, and common conversation in the past two decades but the root of the word and the concept as applied to development has been around since the early European enlightenment. In 1713 Hanns Carl von Carlowitz, the head of the Royal Mining Office in Saxony coined the word (*nachhaltig* in German) in reference to timber management practices (Grober, 2007). It was "Our Common Future," also known as the Brundtland Report, written in 1987 that projected sustainability and sustainable development onto the global stage. Lockwood (2003) reviewed the subsequent definitions of sustainability that appeared and have been applied to the rural water and sanitation sector. His review is summarized in Table 1. Included in the table are relevant publications, both those cited by Lockwood (2003) and more recent publications. The ten examples provided in the table are not a comprehensive set of definitions because sustainability is dependent on perspective and therefore influenced by the individual or group seeking to define it.

Table 1: Varying definitions and descriptions of sustainability relevant to the rural water and sanitation sector. Table derived from a review of post-project sustainability conducted by Lockwood (2003).

Sustainability Focus	Definitions/Descriptions	Sources/Related Citations
Environmental	Use or degradation of resources at a rate less than or equal to their replenishment or assimilation rates.	General
Ecological	Ability of an ecosystem to maintain ecological processes, functions, biodiversity, and productivity into the future.	REO (2009)
Institutional or Management	"Prevailing structures and processes have the capacity to continue their functions over the long term."	DFID (2000)
Economic	Within water and sanitation sector: financial aspects of service delivery and self-sufficiency of projects and cost sharing (user fees) even in low-income communities.	Black (1998)
Project	A project is sustainable if 1) sources not over-exploited 2) facilities maintained 3) benefits continue 4) project process cost-effective	Mancinni et al (2004) Harvey et al (2003)
Social	Socio-cultural respect, community participation, political cohesion	McConville et al, (2007)
Pragmatic	"Whether or not something [infrastructure] continues to work over time."	Abrams (1998)
Triple Bottom Line: Ecological, Economic, Social	"Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs."	WCED (1987) Mihelcic et al (2003)
Flow of Benefits	Perceived benefits of projects. An improvement in the health and the subsequent positive impact on the broader welfare of the rural populations."	Lockwood (2003)
	"The resilience to risk of net benefit flows over time."	OED (2003)
Social Equity (gender and economic capacity)	Satisfactory functioning and effective use of services by everyone (men and women, rich and poor) having equal access to benefits	Mukherjee and van Wijk (2003)

Our objective is to obtain the most utilitarian definition for the rural water sector-inclusive of the needs of beneficiaries, requirements of governments and societies, and limitations of resources (environmental, financial, human, etc). The flow of benefits is an aspect of patent importance in sustainability, however, in addition to measuring the flow of benefits, it is important to evaluate how they are utilized and distributed (Lockwood, 2003). Equitable access among genders and between socio-economic classes is a critical concept raised by Mukherjee and van Wilk (2003). Another important concept, supported in recent literature, is the idea that sustainability does not exclude long term relationships between a community or community management (CM) organization and an external support institution (Lockwood, 2002; Schouten and Moriarty, 2003; Rosenweig, 2001).

In addition, donors and government agencies tend to focus on economic indicators of sustainability, civil society and development institutions focus on project, managerial, or social indicators while often users are only concerned with the flow of benefits or a pragmatic bottom line: service and convenience.

Therefore consistent with the utilitarian view, for this research sustainability in a rural water system in the developing world will have the following: 1) Equitable access amongst all members of a population to continual service at acceptable levels (quantity, quality, and access location) providing sufficient benefits (health, economic, and social) and 2) Require reasonable and continual contributions and collaboration from service beneficiaries and external participants.

1.3 Framework for Measuring Sustainability

Many different frameworks have been used to measure the sustainability in development listing dozens of factors affecting sustainability and the indicators measured to determine the impact of each factor. The focus of this analysis is on the **long term (e.g. post project) issues in community operation and maintenance of rural water systems in the Dominican Republic** and therefore the analytical framework must reflect appropriate factors and subsequent indicators. Lockwood (2003) evaluates different frameworks used to evaluate post project sustainability and concludes that the factors fall into six general categories.

1. Technical
2. Community and Social
3. Institutional
4. Environmental
5. Financial
6. Heat

In addition to this classification the factors can be separated by whether they fall within the sphere of control of the community (willingness to pay, social capital or cohesion, and motivation) or out of the communities' hands (legal framework, technical design, water source, spare parts availability, and institutional support). Not all factors are exclusively internal or external and, instead, are dependent upon variables from each. An example is the management capacity of the community which is affected by the human resources within the community (internal) but also the supply of institutions willing to train community members (external). The Data Analysis section contains a more extensive discussion of the sustainability framework.

1.4 Background: The Dominican Republic

1.4.1 Geography

The geographic make-up of the sub-tropic island of *Hispaniola*, the second largest of the Antilles archipelago located between 17 and 20 degrees north and longitudes 68 and 72 degrees west latitude, results in an incredibly diverse and varied climate. The island chain of the Greater Antilles was formed by a concurrence of underwater tectonic ridges originating in Central American and connecting with the volcanic isles of the Lesser Antilles (Moya Pons, 1995). *Hispaniola* is bordered to the north by the Atlantic Ocean, the east by the Mona Passage, the south by the Caribbean Sea, and the west by the windward Channel. The climate on the island is shaped by interactions between the prevailing "trade" winds with the five mountain ranges, the Septentrional, Central, Neiba, Oriental, and Bahoruco ranges that run southeast to northwest on the island. The warm wet air coming off of the Atlantic loses its moisture as it passes over the mountains causing a humid tropic environment on the windward side of the mountains and a dry "rain shadow" effect on the leeward side (see Figure 1).

Figure 1: The Island of Hispaniola contains five mountain ranges: Cordillera Central, Septentrional, and Oriental and the Sierra de Neiba and Bahoruco shown on the large map created using NASA (2009) map. Inset map shows the position of Hispaniola, circled in red, relative to the land masses of South and Central America, modified from a CIA (2002) map.

Hispaniola is the only island in the Caribbean that is divided between two nations, Haiti and the Dominican Republic, each with dissimilar geographical patterns and resulting climates. The Dominican Republic (DR) occupies the eastern two thirds (18,816 square miles) of the island (See Figure 2) and enjoys a diverse array of microclimates including: alpine forest, subtropical forest, rich valleys, grasslands, dry chaparral, lakes, deserts, and swamps. The DR benefits from its position on the windward side of the island, due to the fact that the prevailing winds off the ocean deposit their moisture on the eastern side, "leaving the Haitian territory with little rainfall for productive agriculture" (Moya Pons, 1995). With fertile alluvial plains in the Cibao and San Juan valleys, the DR reports that 22.5% of the land is arable and suited for crops such as wheat, maize, and rice. Approximately 10% of the land is occupied by perennial crops such as cacao, coffee, avocado, mangos, and citrus with the remaining 67% occupied by meadows, pastures, forests, and urban environments (CIA Factbook, 2009). Major agricultural exports are sugar cane, tobacco, coffee and cacao while the principal crops grown and domestically consumed are rice, plantains, tomatoes, bananas, and yucca (ONE, 2007).

1.4.2 Climate

Like other Caribbean nations the climate of the Dominican Republic is relatively stable. Climatologic data presented in Table 2 shows the climate is temperate. Average humidity ranges between 68 and 86%, and average mean temperatures range from 19.2 degrees Celsius in the Central Mountains where elevations reach over 3,000 meters above sea level to 28.8 degrees Celsius near Lake Enriquillo, which is 46 meters below sea level (ONE, 2007).

Table 2: Ranges of average percent humidity, temperature, and rainfall in the Dominican Republic (ONE, 2007).

Range of Averages	
68 –86	Humidity (%)
19.2-26.8	Temperature (degrees Celsius)
500-2500	Rainfall (millimeters/year)

Average rainfall is 1,346 mm, with the maximum in the northeast (2,500 mm) and minimum in the west, locally referred to as "the south" (500 mm). This produces an abundance of renewable fresh water resources, estimated at approximately 20,000 million cubic meters per year by the National Hydraulic Resource Institute (INDRHI/OEA, 1994). Total freshwater usage is 3.39 million cubic meters per year, or 381 cubic meters for each of the 9,507,133 inhabitants (2008 estimate) every year. This usage is divided in the following sectors: 32% is domestic, 2% industrial and 66% agricultural (CIA Factbook, 2009). Overall, the island enjoys an agreeable climate with moderate temperatures and sufficient rainfall. This, combined with fertile soils, supports the diverse flora and fauna that is characteristic of the island and attracted the first inhabitants.

1.4.3 Anthropological History

The first migrants to Hispaniola are called "pre-ceramist archaic groups" by anthropologists and it is believed these groups arrived more than 3,000 years before the Common Era. Another migrant group to arrive before the European explorers/colonizers was the Arawak-speaking hunter-gatherers *Tainos.* The *Tainos* inhabited the island, which they termed *Quisqueya,* since at least 600 AD, during which time they introduced important crops like *yucca* (manioc), *maiz* (corn), *batata* (sweet potato), and *mani* (peanuts) (Moya Pons, 1995) that were brought over from South America. Europeans arrived on Hispaniola in December 1492, and although Christopher Columbus never set foot during his maiden voyage in present day DR, his brother Bartolome, fleeing a revolt, founded the city of La Isabella near present day Santo Domingo (Moya Pons, 1995). Since that time, due to the Dominican Republic's strategic maritime location on the Mona Passage, it has played an important geopolitical and economic role in the region. French and the Spanish laid claim to the island, British buccaneers raided settlements, sacking and burning the city of Santo Domingo, and in the twentieth century the United States military would invade and occupy Haiti and the DR twice each.

For over three centuries after the European "discovery" of Hispaniola, a tug of war played out between Europeans and local inhabitants of both *creole* and *latino* origin. In 1804 Haiti achieved sovereignty, becoming the first independent black republic in the world, and fearing continued European interference conquered the eastern two-thirds of the island, taking it from the Spanish. After various internal and external struggles, independence was achieved from Haiti in 1822, as the Spanish speaking Dominican Republic. The first constitution of the DR was modeled after the US Constitution and signed on November 6, 1844.

Figure 2: Political map of the Dominican Republic showing the 31 provinces and the national district as well as major cities and roadways (CIA, 2004). Inset is the Dominican flag (CIA Factbook, 2009).

The Dominican Republic is a unitary republican state with democratically elected representatives in the legislative branch (Senate and Chamber of Deputies) and a President who runs the executive branch. The country is politically and administratively divided into 31 provinces, the national district, 154 municipalities (15,000 or more inhabitants), 226 municipal districts (10,000-15,000 inhabitants), and 380 independent administrative units (those outside jurisdiction of the former). Figure 2 shows the locations of the provincial political divisions as well as the major transportation routes in the country. There are estimated at over 8,600 communities in the Dominican Republic, most of them small and rural (Johnson *et al*, 2002).

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2 Water and Sanitation Sector in the Dominican Republic

As the new millennium approached leaders around the world gathered and drafted a list of challenges facing the planet and the development objectives to which humanity would strive. What resulted was the Millennium Declaration which was adopted by 189 nations and signed by 147 heads of state during the UN Millennium Summit in September 2000. It contains eight Millennium Development Goals (MDG) addressing poverty, health, education, gender equality, and the environment. A key element within the MDGs is access to water and sanitation. Water is a key driver to reaching these development objectives and a necessary condition for productive and healthy lives, and therefore human development and poverty reduction (Thematic Group Scaling Up, 2005). Water and Sanitation is addressed by MDG 7 Target #10 which is to reduce by the half (with 1990 as a baseline) the proportion of people without sustainable access to safe drinking water and basic sanitation. Four indicators are used to measure the progress towards the target:

Indicator 30a: Urban potable water coverage

Indicator 30b: Rural potable water coverage

Indicator 31a: Coverage of adequate excreta disposal in urban zones

Indicator 31b: Coverage of adequate excreta disposal in rural zones

Each indicator has respective sub-indicators that strive to define exactly what will be measured in each country to define the coverage level. For indicator 30 an "improved water source" is defined by the United Nations as any one of the following: piped water, public standpipes, borehole or pump, protected well, protected spring or rainwater, but excluding vendor provided waters, bottled water, tanker trucks, or unprotected wells and springs. "Reasonable access" signifies providing at least 20 liters per capita per day at a distance no greater than 1,000 meters.

The Secretary of the Environment and Natural Resources (SEMARN), the organization in the DR charged with MDG 7 progress reporting, released a report in 2006 with the quantified targets to be reached by 2015 (shown in Table 3). SEMARN (2006) states the goal to supply 1,423,571 rural inhabitants with potable water by 2015; 40% with household connections and 60% with appropriate solutions or "improved water sources." However, from this publication, it is unclear what the final target (e.g. overall percent) is for rural areas. If the national goal (99.4%) is less than the urban goal (99.9%), then by the law of averages the rural goal must be less than 99.4%. In either case the goals have been scaled back from previous figures. In 2000 the goal to be reached by 2010 was universal coverage in RWS-75% household connections, 25% improved access of minimum of 500 meters (PNUD, 2000).

Table 3: Specific values for the Dominican Republic Millennium Development Goal 7, Target 10, Indicator 30: Potable Water Coverage for Urban Areas and the Nation as reported by The Secretary of the Environment and Natural Resources (SEMARN, 2006).

Concept	Indicator	MDG Target
Potable Water: Urban Areas	**30.a** Potable water coverage	99.9%
	30.a.1 % systems with chlorination	100.0%
	30.a.2 % systems with sanitary (residuals) control	100.0%
	30.a 3 % metered water	45.0%
Potable Water: National Level	Water coverage	99.4%
	% systems with chlorination	100.0%
	% systems with sanitary (residuals) control	85.0%

2.1 Access to Potable Water: Where are we?

2.1.1 Statistical Reporting

As is common in development, a myriad of organizations both national and international have conducted research and released findings on the access to potable water and sanitation in the Dominican Republic. Due to a lack of standardization, coverage is reported by population and/or household, for drinking water and/or for general use water, and "access" has different definitions. In general, the statistics can be divided into two categories, those that use a broad definition of access or those that use a narrow definition of access. The narrow definition of access (listed previously) used by the UN is also used by the National Statistics Office (ONE) and the National Household Survey (ENHOGAR). The National Demographic and Health Survey (ENDESA) defines access as 15 minute trip from the home to the drinking water source with the caveat being that bottled and tanker water is included as an improved water source. The ENDESA 2007 survey is the most recent study of access to water and sanitation in the DR and is shown in Table 4 along with ENDESA 2002 data.

Table 4: The National Demographic and Health Survey (ENDESA, 2007) results show a large increase in the percentage of homes with access (15 minute round-trip) to an improved drinking water source such as a piped water, public standpipes, borehole or pump, protected well, protected spring, rainwater, tankered, or bottled water.

Year	% Homes within 15 minutes of Water Source		
	Urban	Rural	Total
2002	79.8	50.6	69.5
2007	95.8	86.4	93.0

To make sense of the differences in statistics, the data was plotted to see if any trends were observable (See Figure 3). The trend assessment procedure used by UNICEF and the World Health Organization in the Joint Monitoring Programme (WHO/UNICEF, 2006) and the Dominican Government (SEMARN, 2006) is linear regression. The data with the highest correlation (R^2= 0.9927) is that created with the results from the National Statistics Office (ONE) Census for household level coverage. ONE uses an objective metrics (the presence or absence of a connection for each house) while EDESA uses a more subjective metrics (15 minute walk from the home).

Although the existing data for ONE follows a linear relationship these trends can not be used as a rigid predictor of future coverage levels. Given the logistical difficulties associated with providing household connections in extremely isolated areas in the mountainous regions (low population density, high depth to ground water, availability of feasible gravity sources) and in addition to the political constraints (marginal cost per person verses marginal political benefit, etc) analogous to a law of diminishing (political) returns, it is likely that access will be asymptotic with a small fraction always seeking service provision. Therefore "universal" coverage will always mean a marginalized group who seeks the services.

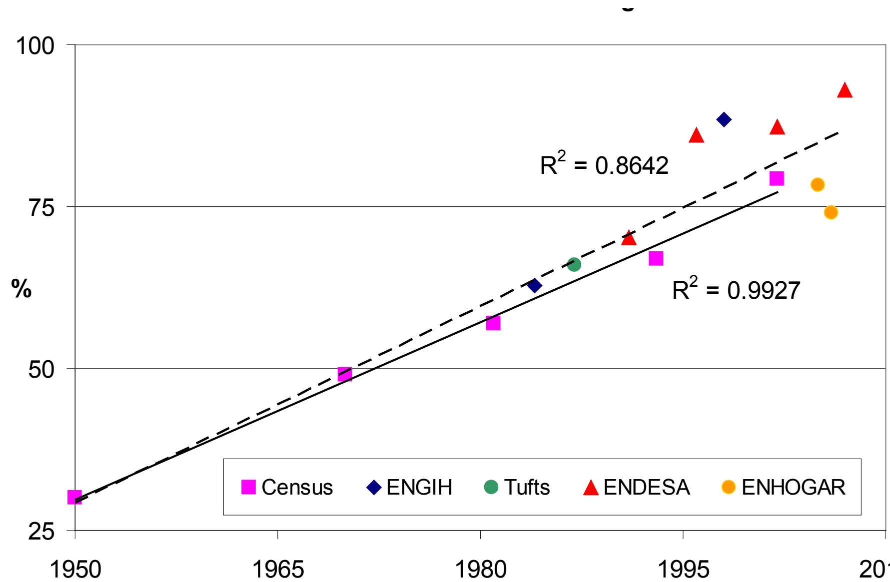

Figure 3: National Potable Water Coverage in the Dominican Republic from five different publications a) National Census b) ENGIH c) Tufts d) Demographic and Health Survey (ENDESA) e) National Survey of Domestic Income and Expenditures (ENHOGAR). A linear regression analysis for each data set showed the highest correlation for the census data (solid line, R=0.9927). The second highest correlation (dashed line, R=0.8643) is from all data points combined, despite the fact that the different surveys used different definitions of "improved access."

The Dominican government currently recognizes 510 aqueducts (the term means piped water supply) serving 787,566 households with indoor connections and even more with outdoor connections at varying distances from the home (Rodriguez, 2008). This is in addition to the numerous systems built by NGOs with varying levels of service whose exact total is unknown (see Methodology Section for further discussion). Sanitation coverage is much lower, only 50 sanitary sewers with 248,118 connections are in operation (Rodriguez, 2008). Although any water supply and sanitation coverage over 50% sounds good compared to the dismal statistics coming out of Africa, according to the Pan American Health Organization, UNICEF, and the Inter-American Development

Bank, the problems in the rural areas of the Dominican Republic are some of the most serious in the hemisphere (Karp *et al.*, 1999).

2.1.2 Rural versus Urban Coverage

As the Dominican government struggles to cope with water supply and sanitation needs of the rapidly growing urban areas, and in particular the burgeoning urban slums, the rural areas become a lesser priority. Figure 4 shows that access to potable water and sanitation services in rural areas is lagging significantly behind access in urban and peri-urban areas. Although drinking water and sanitation services represent a large portion of the government's social expenditures, of the country's 9,722 rural communities only about 25% of them had drinking water services in 2006 (ENHOGAR, 2006). This is a common situation, as worldwide the portion of funds spent on water and sanitation projects in poor rural or peri-urban communities is estimated to be only 5 to 10% of the total water and sanitation budget (Jolly, 2004).

Between 1990 and 1998 the Dominican government spent 87.9 million USD on potable water projects of which only 16.1% went to rural areas and 83.9% to urban centers (SEMARN, 2006). Often funds are channeled into urban projects where it is believed they can be stretched further due to higher population densities, however, economy of scale benefits are not achieved. The average annual per capita expenditures between 1990-1998 on urban systems ($17.35) is significantly higher than rural systems ($4.38) (Abreu, 1999). The co-director for the rural aqueducts program of Spanish Agency for International Cooperation (AECI) in coordination with INAPA stated succinctly one important reason for this inequity in funds distribution, "They [rural communities] do not give [politicians] votes, and that is all that matters in the politics" (interview Reyes 12/2008). Power is concentrated in the provincial capitals and Santo Domingo.

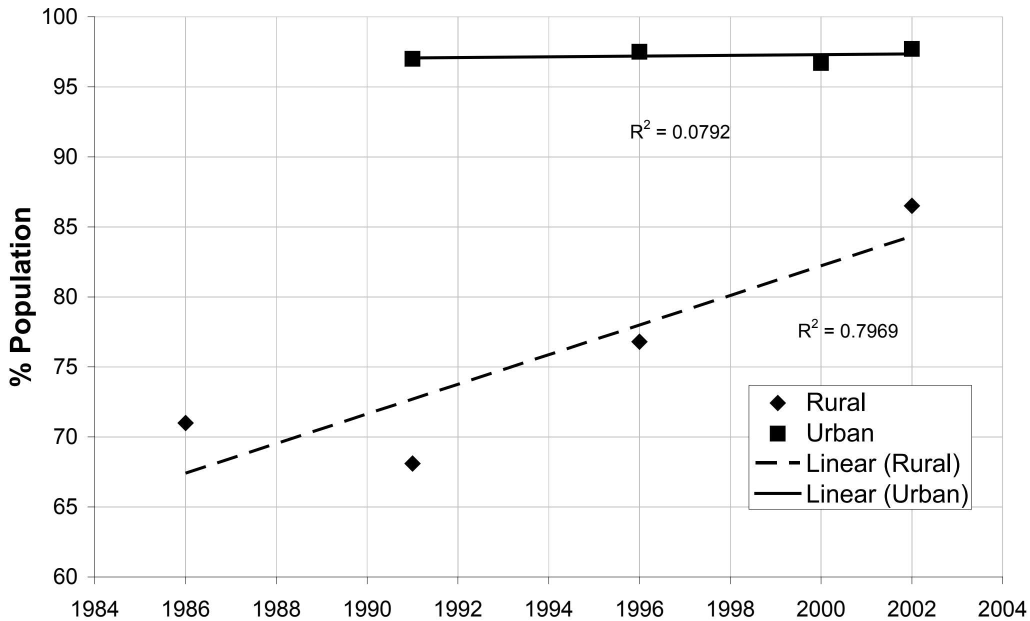

Figure 4: The Difference in Improved Access to Drinking Water between rural and urban areas in the Dominican Republic. Improved access is defined as a 15 minute maximum round trip from the home to the drinking water source such as a piped water, public standpipes, borehole or pump, protected well, protected spring rainwater, tankered, or bottled water (WHO/UNICEF, 2006).

Using the World Bank definition of poverty of living on \$1 to \$2 a day (moderate poverty) and less than \$1 a day (extreme poverty) and statistics from the National Planning Office of the President of the DR, the number of rural homes in poverty is 41%, and the number in extreme or absolute poverty is 8% (ONE, 2007). Even more staggering is the fact that, despite serious urbanization, there are more people living in extreme poverty in rural areas (389,524) in the DR, than in urban areas (247,747) (ONE, 2007). Furthermore, the percentage of families living in general poverty in rural areas is higher than the percentage in urban areas- 55.6% and 32.6% respectively (Morillo Perez *et al*, 2005). The World Bank socioeconomic classification system that evaluates home construction materials, access to basic services, and possession of certain consumer goods that are related to wealth and well being, shows 42.9% of people in rural areas in the poorest fifth of the national population, while only 9.9% of people in urban areas are

(Morillo Perez *et al*, 2005). The implications of the disproportionate resource allocation and disparity in wealth between urban and rural area are substantial and far-reaching.

An important and powerful indicator of this inequality is the time dedicated to water collection. A study conducted by AECI (2001) showed that the time dedicated to water collection by the poorest 20% in the DR is four times more than the time dedicated by the wealthiest 20%. The daily struggle in search of water is a burden that is almost universally borne by women and children. This seriously limits the time dedicated to income generating activities, personal development, and most importantly education. These factors contribute to the feminization of poverty, which has resulted in disproportionate incidence of poverty among women: 70% of the poor worldwide are women (World Bank, 2006). Unfortunately the water and sanitation (WAS) situation in the DR is reflected worldwide, where of the nearly one billion people living without access to improved water services, 75% live in rural areas (WHO, 2008). These statistics have a disproportionately negative affect on rural areas where in addition to low potable water and sanitation access there is a severe lack of access to medical care.

Lack of access to these basic services: water, sanitation, health care, as well as primary education and infrastructural deficiencies (electricity, irrigation, and transportation), are the main factors that contribute to a cycle of poverty (Sachs, 2005). An expert in the field of water supply, sanitation and environmental health with 20 years experience worldwide, including the DR, states that "the provision of sustainable water services to the rural poor is one the most important, difficult, and neglected areas of development" (Lockwood *et al*, 2009). For these reasons the focus of this research is on Rural Water Sector (RWS) within the broader Water and Sanitation Sector (WAS).

2.1.3 Water Quality

Another issue, correlated to access, plaguing RWS is the issue of water quality. Despite the significant water resources available in the Dominican Republic, studies conducted by various organizations both governmental and non-governmental show that surface and groundwater in the country are contaminated with biological or chemical contaminants (UNDP, 2000). This is due to a lack of adequate sanitation and infrastructure planning, poor soil conservation and erosion control techniques, and the heavy use of fertilizers, pesticides, and herbicides (UNICEF, 2000). Reports confirm that inadequately treated urban residuals and industrial discharges, as well as agricultural runoff and over exploitation of underground aquifers causing saltwater intrusion were the principal culprits for contaminating water sources in the DR (Abreu, 2000).

According to the National Demographic Survey of Health conducted in 2007, approximately 400,000 people (4.1% of the population) did not have any form of sanitation (toilet, latrine, or other), and 8.1% in rural areas and 2.3% in urban areas, and resorted to open defecation (ENDESA, 2007). The result of these activities is that 87% of the shallow wells in the country have bacterial contamination (PNUD, 2008). The potability index is a measure of water quality that reports the percentage of samples free of total coliforms (indicator of fecal contamination) in distribution networks in the DR. Figure 5 uses the potability index to show that the water quality has steadily declined over the past decade (Rodriguez 2008). This has created a lack of confidence in water quality from piped systems.

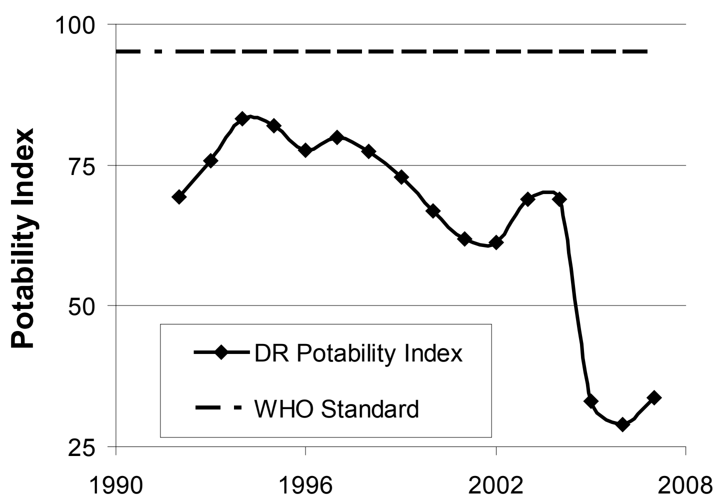

Figure 5: Composite Potability Index (PI) of water samples collected from distribution networks of different water systems run by the National Institute of Potable Water and Sanitation (INAPA acronym in Spanish) of the Dominican Republic. PI measures the percentage of samples free from total coliforms. The World Health Organization standard is PI 95%.

As a reaction to the poor water quality, 55.7 % of the population currently uses bottled water as their principal source of drinking water (ENDESA 2007). This not only diverts attention away from public infrastructure but also significant resources. Assuming these 55.7% of people drink a half liter a day at corner store prices (5 gallon *botellon* = 1.25 USD), every year approximately 65 million USD (author's estimate) are spent on bottled water. Furthermore, lack of adequate regulation of bottled water quality creates a false sense of security amongst consumers. Reverse osmosis is the preferred water treatment method amongst bottle water companies; 98% of companies in 1993 used osmosis. Without monitoring and standardization of procedures, the quality of this water cannot be ensured (Abreu, 1996). Yet there are problems at the other end of the spectrum as well. If the process works as designed, it removes all minerals from the water. Water can be an important source of essential minerals and can contribute up to 36% of the recommended dietary needs of some minerals such as calcium (Abreu, 1996). Concerns regarding malnutrition and mineral deficiency in the DR and the foregone benefits associated with the excessive consumption of bottled water, as opposed to mineral endowed "natural water," have also been expressed by the Pan American Health Organization (Abreu, 1996).

2.1.4 Sector Investment

Similar to other countries in the Caribbean, investment in the water and sanitation sector in the DR is limited. In 2005, expenditures in water and sanitation represented 0.6% of Gross Domestic Product and only 2.6% of total public expenditures (Lizardo 2006). Although internationally, the water and sanitation sector has experienced a continual increase in the level of investment, in the DR investment decreased significantly from the mid-90s while during the same time GDP increased and the economy enjoyed significant growth (see Figure 6).

A high level of resource allocation by the central government to potable water and sanitation system institutions in the past two decades has had a limited impact on the health and well-being of the population because the "procedures which it is supported are deficient in that they do not promote self-sufficiency [of these institutions]" (USAID 2006). In addition the funds are almost exclusively devoted to construction of new works and little is dedicated to enhancing the operations and maintenance of existing systems (Rodriguez, 2008).

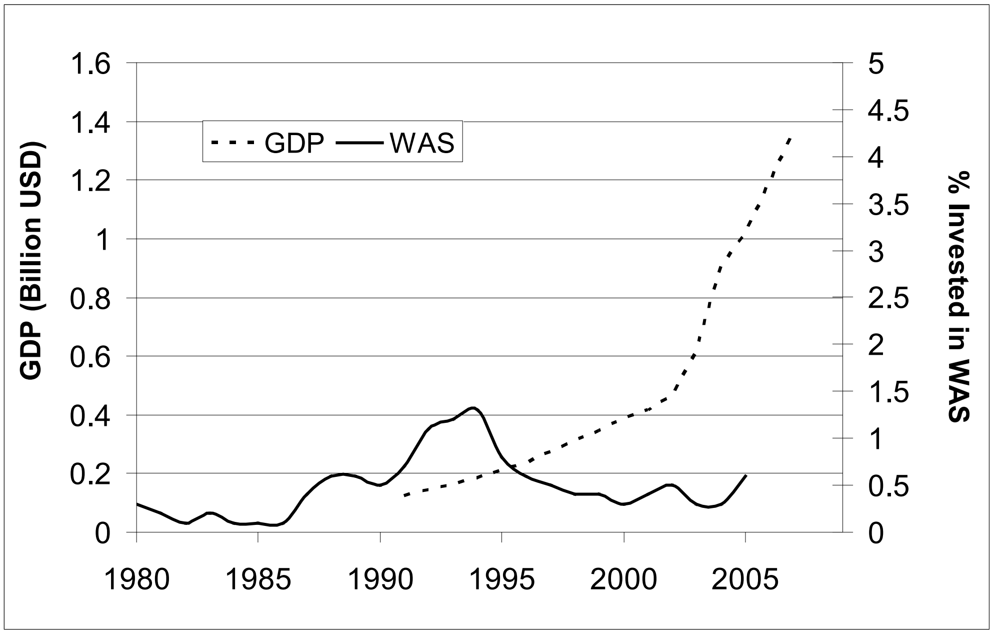

Figure 6: Gross Domestic Product (GDP) of the Dominican Republic and the percentage of GDP spent on the Water and Sanitation Sector (WAS). WAS data was obtained from the National Planning Office (ONAPLAN, 2005) and the GDP data was obtained from the Central Bank (www.bancocentral.com.do Retrieved on February 22, 2009).

2.2 Obstacles to Improved Access: Why are we here?

2.2.1 Macro Economic Factors and Indicators

As shown, in Figure 6 above the Dominican Republic has enjoyed significant economic growth over the past ten years, however, these benefits have not necessarily translated into development, nor have all segments of the population enjoyed the same development. There are various other indices used to evaluate a country's development status and capabilities. Purchasing power parity (PPP), a measure of the relative per capita income generation, was 6,600 USD per person putting the DR in middle of the pack worldwide (125 out of 229). However this figure hides the high income disparity, as the richest 10% in the DR account for 41.1% of the country's wealth and the poorest 10% eek out a meager existence with 1.4% of the wealth (CIA Factbook, 2009).

The Gini Index, an international indicator of income disparity, in the DR was 49.9 (111th out of 146 countries) in 2005 (CIA Factbook, 2008). This disparity in wealth is reflected in a disparity of water and sanitation access. In 2006, 86.6% of the richest fifth had access to an improved drinking water source while only 55.5% of the poorest fifth enjoyed the same level of access (ENHOGAR, 2006). Income disparity has been cited as the reason that the Dominican Republic occupies the position as the second worst country in the Latin American and the Caribbean (behind only Granada) when comparing economic growth and human development; even Haiti has done more relative to their economic growth (World Bank, 2005).

Another widely utilized index of development is the World Bank's Human Development Index (HDI), a measure of achievements in education, life expectancy, literacy, and GDP per capita. The HDI for the Dominican Republic is 0.779 out of a possible 1.0 putting the DR 79th out of 194 countries studied. This is just above Belize and China (80th and 81st) but behind 18 other countries in the western hemisphere including other Caribbean island nations: Barbados, Bahamas, Cuba, Saint Kitts and Nevis, Antigua and Barbuda, Trinidad and Tobago, Dominica, and Santa Lucia (in order of descending HDI). With one of the strongest economies in the Caribbean this is an embarrassing statistic for the DR. Of the 89 countries with HDI data available dating back to 1975, the Dominican Republic's relative position is rapidly slipping as other countries pass it by (World Bank, 2005).

The Quality of Life Index, created by The Economist Intelligence Unit (of *The Economist* magazine) is an attempt at an objective development metric that uses health, financial, political, social, and other factors. The quality of life index of the DR increased in the 90s until 2002, since which it has declined steadily (Leon, 2006). Currently the DR is ranked 79 out of 195 countries for the Quality of Life Index (CIA Factbook, 2009). Besides these economic based development indices, (PPP, Gini, HDI, and Quality of Life) there are important demographic factors and population dynamics that affect water and sanitation improvements.

2.2.2 Demographic Factors and Population Dynamics

Urbanization as a social and cultural phenomenon is a significant obstacle to improving access to water and sanitation in the DR as it burdens providers in urban and peri-urban areas and draws attention away from rural areas where the coverage is actually lower. In the Dominican Republic, like other developing nations, rapid population growth (2009 estimate of 1.49% per year), massive migration to urban areas (about 40% of people in urban areas where born in rural areas), and an increasing number of people living in poverty has resulted in serious deficiencies in the coverage and quality of water and sanitation services, especially in rural areas (as discussed previously in Section 3.1.2) (CIA Factbook, 2009). The federal government, international development agencies, NGOs, religious organizations, and private sector actors are often faced with a tough decision: to focus on these rural areas where coverage levels are lower or, especially when faced with decreasing budgets from international economic slowdowns, to focus on urban areas to maximize the number of people benefitted by interventions. The implications of these decisions can cause further exacerbate internal migration away from rural areas and burden infrastructure in the cities and peri-urban areas.

Rural areas, characterized by subsistence farming and stagnant or negative population growth (due to urbanization), are also hindered by low levels of vaccination coverage, drinking water availability and hospital utilization (Leon, 2006). This is especially the case in the rural southwest provinces of Independencia, Pedernales, Bahoruco, and Elías Piña along the border with Haiti where the author served as a Peace Corps Volunteer. During two years of service, October 2006 to November 2008, over two dozen people of a population of 325 (~10%) left the community for the provincial or federal capital.

According to the 2002 census the majority of internal migrants were adult (18-65) more often women (58%) from poor agricultural areas moving to urban areas to work in manufacturing or the service industry (UNDP, 2008). The provinces with “intensive agricultural activity” register a higher emigration rate (UNDP, 2008). In this author’s experience in Elias Piña, the province with the highest percent rural poverty in country and 3rd highest emigration rate, the factors that drive the migration from rural areas can be divided into three general categories, as listed in Table 5.

Table 5: Rural Migration Categories and the Main Driving Factors for Each Category. Factors were derived from the author’s experience in the border province Elias Piña which has the highest percent rural poverty in country and 3rd highest emigration rate. The statistics cited are from the United Nations Development Programme Report (UNDP, 2008).

Restless Youth	Middle-aged Farmer/Housewife	Elderly
• 10 to 29 years old • Drawn to pop culture and glamour of urban centers • Little/ No connection to agrarian lifestyle • Accounted for 51% of all internal migration in 1997	• 30-64 years old • Struggling with fluctuating commodity prices (global economy) and severe climatological events. • Impacted by cash based society (more goods are extra local) and lack of inexpensive labor (youth) • Traditional work cooperatives exchanged for cash payments to day laborers, often Haitian. • Men seek construction jobs (9%), industrial manufacturing (17.9%), or street vending (26%) • Women take domestic jobs (40.6%)	• 65+ years old • Encouraged by children, grandchildren or extended family to seek the “convenience” comforts of the city. • Highly connected to land, but ailing health often makes farming impossible. • Health concerns coupled with access issue often precipitate a move.

Restless youth (10-29) accounted for the over 51% of all internal migrants in 1997 (ONE, 2007). They are drawn to the pop culture and glamour of urban centers and have lost the connection to the agrarian lifestyle of their parent’s generation. “Middle-aged” farmers/housewives (30-64) struggle with fluctuating commodities prices and increasingly severe climatological events that limit the economic potential of *campo* (country) life. They also feel the impacts of an increasingly consumerist society in which more goods are extra local and require cash to obtain and traditional cooperative work arrangements between farmers have been substituted for cash payments to *braceros* or day laborers. Elderly people (64+) who are unable to work and live off small government pension (~30 USD per month), intermittent welfare packages, or remittances from family members move to city to live with families. Despite being highly connected to their lifestyle and the land, they are motivated by ailing health, limited access to healthcare, and the modern conveniences of city life. These factors contribute to an elevated unemployment rate (15.4%) in the DR, nearly twice that of the United States (ONE, 2007).

2.2.3 Political Factors

Another aspect that can be seen as an obstacle to improvement in RWS is the proliferation of paternalism. Historically, the Dominican Republic has been ruled by a series of *cuadillos* or strong-men. After the overthrow of the Spanish in the War of Restoration in 1864 through the dictatorship of infamous Rafael Leonidas Trujillo, Dominican politics has been plagued by many power-hungry opportunistic leaders who assume leadership through corrupt, undemocratic means. Once in power these *cuadillos* exercise their power to make themselves and those around them rich. Under authoritarian leadership models democratic or other participatory processes may suffer, but certain initiatives, when supported by the centralized power, can be incredibly efficient if the masses are subjugated (willingfully or not). The order evoked by the fear that Trujillo perpetuated during his 32-year tenure in power promoted a cultural belief, especially in rural areas and amongst members of the older generations, that the natural order is for top down or centralized decision making. Reliance on a *cuadillo* is reflected in the vertical and centralized organizational structure that is today common in many governmental agencies within the water and sanitation sector (Rodriguez, 2008).

Like authoritarianism, the other two important political factors that affect development in the Dominican Republic, are nepotism and corruption. Dating back to the early land grant system of *repartamientos*, whereby land was granted to nobility held in the king's favor, nepotism and corruption have been important factors that govern decision making and impede progress. The magnitude of the effects is so overt that government institutions can expect to loose large percentages of their workforce if the political party changes power. High turnover leads to low institutional knowledge and hence efficiency. Nepotism does not foster appropriate coordination between supply and demand in human resources, and without proper institutional planning (caused by leadership changes) water and sanitation organizations contract unnecessary employees with inappropriate qualifications (Rodriguez, 2008). As an example, the National Institute for Potable Water (INAPA acronym in Spanish) in the DR employs 18.7 people per 1,000 connections, while efficient operators in other countries employ less than 3 people per 1000 connections (Rodriguez, 2008). Of the eight employees in the social promotions division at INAPA with whom the author worked, 5 were hired after the last political party power shift of the 2004 presidential elections. Uncertainty of the future is also extended from the individual to the organizational level as a bill proposing far-reaching changes for INAPA has been stuck in the legislature for years. It is unclear when or if sector reform will occur.

As with any discipline in development, it is critically important to have adequate understanding of the history and cultural context of the rural water sector: to understand "where we are" and "why we are here." Building upon this, it is possible to evaluate lessons learned in the field internationally, so that an effective organizational strategy can be developed.

3 Organizational Strategies in Rural Water Systems

3.1 General Policy Approaches

3.1.1 Supply-Driven Project Approach

A supply-driven project approach focuses on the design and construction of new systems based the availability of investment resources and the perceived needs of the population. Often this approach emphasizes health impacts but does not address the actual demand for services or the potential for a maintained service level in the long term (Sara and Katz, 1997). Under supply driven project approaches, communities are not necessarily involved in the planning and design phases, and their contribution, often in-kind (labor, materials, or land), is not reflective of the actual demand for the service. In addition, provision for the operations and management phase is not systematic or adequate because of the project based (and hence finite) scope. The history of this approach is rooted in the 1980s.

The United Nations Declared the 1980s as the International Drinking Water Supply and Sanitation Decade (IDWSSD) with the goal to provide safe water and sanitation services to everyone by 1990. An ambitious goal, the actual percentage of people living without safe water supply went from 56% in 1980 to 31% by 1990, yet this reduction "barely kept pace with the growth of the population" in other words the absolute number of people without access stayed almost the same (Carter *et al*. 1993). The IDWSSD focus was on project results, extending service to as many people as quickly as possible, but in the end the effort failed to address the issue of how to ensure sustained access for the long-term (Lockwood *et al*, 2009). Projected to cost 30 billion $US (Brown, 1983), only 25% to 33% was actually allocated (Carter *et al*. 1993).

Lacking sufficient financial resources the executing agencies circumvented governments and focused on local level operators. This was done in an effort to stretch the available funds, the theory that corruption and bureaucratic inefficiency was the root of the problem. The role of governments was further reduced as international financing agencies (IMF and World Bank) enforced austerity programs, implemented under structural adjustment policies (SAP). These SAPs emphasized privatization and often cut social programs in an effort to balance budgets (Lockwood *et al*, 2009). With less money to spend on RWS and a higher demand for services, the idea for "grassroots" management developed to help stretch funds. The driving force behind the paradigm shift to community level management and operation was the insufficient financing during the IDWSSD (Mathew, 2005).

The concept of village level operation and maintenance (VLOM) was developed to represent what was a complete lack of long term external support. As a result the initial VLOM efforts led rural systems in developing countries into eventual disuse and disrepair. Evaluations showed that cost recovery was minimal, revenues were insufficient to cover operation and maintenance, and user satisfaction was low (Churchill *et al*. 1987 and Briscoe and DeFerranti 1988). A new focus, sustainability in development, was the result of the United Nation's 1987 Brundtland Report. Sustainable development as ¨a process of change in the economic, social, and technological capacities of a community" became the paradigm, and research showed that strong community management leads to sustainable water supply and sanitation systems (McCommon, 1990). The caveat was defining the approach to sustainable development including the principles defining the relationships between development agents and participants.

3.1.2 Demand-Responsive Project Approach

Research conclusions from the 1980s motivated representatives from government, private sector, non-governmental organizations, and intergovernmental organizations to meet in 1992. During this summit they identified four principles to guide action in development of the water sector, outlined in The Dublin Statement on Water and Sustainable Development. It stressed the importance of community participation, especially that of women, who are primary beneficiaries; currently 70% of the poor worldwide are women (WTO, 2003). The statement also stressed using demand to base investment priority, stipulating user contributions, and transferring management to the community when operations begin. The concepts of increased community participation (CP) and the demand-response approach (DRA) emerged and gained ground throughout the 1990s.

Under DRA, households have the choice of the technical, institutional, and governance arrangement and are responsible for all operating and management costs, as well as some capital costs. The rationale was that communities would choose service levels and contribute to capital expenditures to help defray total costs and in turn would be instilled with a sense of project ownership. At the same time these requirements would serve as a “demand filter,” or a test of the community’s prioritization of the project and commitment to running the system after project conclusion. Community participation under DRA gained immediate support from many governments eager to relieve the significant economic burden incurred through indefinite system operation and maintenance.

Although DRA and community management are a step in the right direction, it assumes that participation, community buy in, and, essentially, market forces will ensure long term service provision. Often those that lack access are the extremely poor and therefore capital costs may fall beyond their economic means; moreover, in kind contributions can divert valuable time or energy from other life-sustaining activities (Whittington, 2008). In these cases it can be seen as a moral imperative for developed countries or other external agents to intervene. In addition, an argument exists that rural water systems provide a marginal social benefit *(positive externality)* in health, education, and economics. Therefore to encourage it, the activity should be subsidized externally. This concept, known as the *Pigouvian subsidy*, promotes economic efficiency. This is related to the argument that investment in water, as well as other sectors such as health, education, and infrastructure serves as an economic catalyst to effectively break the cycle of poverty (Whittington, 2008).

Village level operation and maintenance (VLOM), Demand Responsive Approach (DRA), and Community Management (CM) in a **project approach** are overly simplistic and ignore the long term needs of communities. From the lessons of the 80s and 90s “It became clear that community focused approaches are not sufficient: a village is not an island, and nor should it be." (Lockwood *et al*, 2009). Accepting that communities require long term support, the concept of a finite project approach needs to be modified to put the emphasis on sustained levels of service.

3.1.3 Demand-Responsive Service Approach

The paradigm shift from supply driven to demand responsive policies is an important step towards meeting the MDGs in Rural Water Sanitation. Despite this, as previously stated, studies have shown that RWS interventions have a low sustainability rate: BNWP (2009), Annis (2006), and Reents (2003).

The ultimate goal of these "interventions" is to provide access to water, sanitation and hygiene services on a continuous basis indefinitely, and therefore when the emphasis is put on finite project goals or discrete indicators (project cycles completed, communities trained, and systems built) there is a risk of compromising the long-term service sustainability (Lockwood *et al*, 2009). A service delivery approach views: design, planning, implementation, operation and maintenance, and eventual upgrading or replacement of water supplies as parts of a single continuous management cycle (Thematic Group, 2005). From a strictly budgetary perspective this is a critical difference from a project approach. This does not mean that cost must balloon out of control; by implementing appropriate technologies within the operation and management capacity of the community it is possible to keep costs reasonable.

Highly engineered civil works and physical infrastructure solutions are being replaced with broader public health and social interventions with diversified management (centralized-federal and decentralized-local), and most recently these "interventions" have been seen with the perspective of providing an indefinite service and not just executing a project. These shifts in ideology have emphasized the importance of the post-construction activities and the organizational approaches to be used in the long term to ensure sustained service delivery.

3.2 Post-Construction Organization

International agencies have invested significant resources into case studies and pilot projects for strategic planning purposes. Since the early 1990s the United Nation's Environmental Health Programme (EHP) has been working on decentralization in projects in the Dominican Republic, the Caribbean, and Latin America. EHP work was motivated by the lessons learned and policy changes that resulted from the International Drinking Water Supply and Sanitation Decade and emphasized the decentralization of decision making and management of RWS systems. However, this reform process has been slow, and much remains to be accomplished as the structure of the sector remains largely as is has been since the 1960s, with large state corporations in charge of service provision in metropolitan areas, municipal systems for the smaller cities, and development organizations (DOs) or private voluntary organizations (PVOs) managing rural or peri-urban areas (Linares and Rosenweig, 1999).

3.2.1 Management Models

Management of WAS systems can be divided into five general categories, shown in Table 6. These range from public to private and centralized to decentralized. The state company with a national scope and default jurisdiction for all water and sanitation provision in the Dominican Republic is the National Institute for Potable Water and Sanitation (INAPA acronym in Spanish). Government-owned corporations called CORAAs (derived from Spanish *corporación)* arose to meet the special needs of the larger cities and the provinces in which they are located, including Santo Domingo, Santiago, Puerto Plata, Espilliat, and La Romana. Unlike other countries in Latin American, there are no local governments (municipal) that maintain or operate their systems; therefore the population falls under management jurisdiction of either INAPA (61.9%) or the CORAAs (38.1%) (Rodriguez, 2008).

This does not mean that the government maintains and operates all WAS systems in the country; currently at least 19% are operated and maintained by PVOs[1] that use different names, water committees, juntas, cooperatives, but serve the same function (Rodriguez, 2008). This is likely an underestimate of the actual number of systems managed by community groups, due to the fact that many development entities (NGOs, GOs, religious organizations, and private actors) work in the RWS sector, constructing interventions and training communities without informing INAPA or the CORAA. Private for-profit companies play a role in project planning, implementation, and even training activities, but to the author's knowledge no private company is in charge of post construction RWS operation and management. Although private sector participation has been demonstrated in urban areas, studies have shown that the economic viability of service provision is limited to systems serving populations over 20,000 or 25,000 (EHP, 1999). Below this threshold it was determined that economies of scale are difficult to achieve or unattainable altogether because the unit costs rise, and to maintain profitability service quality deteriorates to unacceptable levels.

Table 6: Division of the management of water and sanitation systems in the Dominican Republic expressed as a percentage of total connections. Source of data: (EHP, 1999) and (Rodriguez, 2008).

Management Models		% connections		
		Urban (1999)	Rural (1999)	Total (2008)
1	Government agencies with national scope (INAPA)	60	90	71
2	State companies with local scope (CORAAs)	40	0	10
3	Municipal systems	0	0	0
4	Private voluntary organization / Community management organization	0	10	19
5	Private for-profit systems	0	0	0

Due to the lack of coordination between the various actors in WAS, comprehensive and detailed statistics on the division of management are limited or non-

[1] Private voluntary organization (PVO) is another name for a community management (CM) organization. Community management organizations can vary in their structure, organization, and functions, themes which will be discussed later in Chapter 4 and 5.

existent. A 1999 EHP report showed heavily centralized management of WAS systems in the DR in urban and especially rural areas. Since then three more CORAAs have been created and four more are in the planning stages, thus increasing the percent managed by state-owned enterprises at the provincial level. Through EHP's decentralization program (discussed more in Chapter 4), management of over 80 rural systems has been transferred to CM organizations thus increasing the role of CM in RWS. Furthermore, dozens of NGOs working in the DR each year use CM organizations, encouraging participation throughout the design, implementation, and post-construction phases of a project.

The particulars of CM differ from country to country, but at the heart there are four main principles to CM that make it unique from other management models: participation of and support from all sectors within the community, control (indirect/direct) over O&M activities, ownership (perceived or actual) over the infrastructure, and cost sharing (Lockwood, 2004). Most experts agree that the management of water supply services should take place at the lowest appropriate level and today more and more projects are being designed, implemented, and managed using principles of community participation and community management, with significant benefits to the traditional top-down models (IRC Thematic Group, 2005). Decentralization is generally the accepted organizational approach for management in RWS to empower communities and ensure efficiency and sustainability of services; however, the long term implications and requirements of CM are unknown.

There has been increased emphasis on the need for external support and what institutional mechanisms should be put in place to maintain appropriate service levels (Carter *et al* (1999), Schouten and Moriarty (2003), and Lockwood (2003)). Supportive policies and legislation as well as good governance, accountability, and transparency make up an enabling environment (IRC Thematic Group, 2005). The support role of these agencies within an "enabling environment" has become known as institutional support mechanisms (ISMs).

3.2.2 Institutional Support Mechanisms (ISMs)

The other component to the post-construction phase is the support provided by the implementing or contracted institutions. Although there is broad acceptance of the CM approach for daily operation of rural systems, there is less understanding of what role implementing organizations should take after construction is complete and the systems are operational.

With funding from the World Bank, the International Water and Sanitation Centre (IRC) along with a UK based Aqua Consultants, is beginning a six-year investigation into the factors that affect the sustainable RWS service, including institutional support mechanisms. Management of RWS entails technical, financial, organizational, and political challenges, and although some communities may have the capacity to function without external support, it is clear that many cannot. Therefore the requirements to ensure continued access must be identified.

The EHP has created a wealth of knowledge regarding the organizational frameworks in RWS and expanded upon earlier work in the field (Rondenilli *et al*, 1987) to develop a classification system of the types of ISMs currently in practice. The classification system is summarized in Table 7 as compiled from Lockwood (2003) and *Karp et al* (1999).

Table 7: Classification system for Institutional Support Mechanisms including examples from the Dominican Republic and elsewhere (when not applicable in the DR) (Lockwood, 2003 and Karp et al, 1999)

Institutional Support Mechanisms		**Description**	**Examples**
Centralized		Federal agency/ministry directly works with community management structures	INAPA and INAPA-AR
Decentralized	De-concentrated	Central government agency operates through regional offices	INAPA-AR, Honduran National Water Supply and Sewage Company Technicians of Operations and Maintenance (TOMs)
		Regional have a degree of autonomy	
		Roots in the *circuit rider approach* of the US	
	Devolution Model	Provincial, State, or Local Government has power	Nicaraguan Water Authority
		Often municipalitization	
	Delegated	Central or local government contracts with third party	Honduran Water Board Association (AHJASA)
		Non governmental organization, private company, private volunteer organization	Peace Corps-Dominican Republic
		Corporatization (public/private and subsidized or autonomous)	CORAAs

Decentralization, whether in the form of deconcentration, devolution, or delegation, has as a central axis empowerment of the communities in the self-management of their water and sanitation service provision. Although decentralization of management is generally accepted as the ideal *modus operandi*, decentralization of institutional support mechanisms is not as widely practiced in the DR. The continued roles of governments and civil society vary considerably from country to country. In the Dominican Republic all of the institutional support mechanisms have been tried at one stage or another. Currently INAPA is trying to deconcentrate post-construction support activities to the regional level, but the central ministry in Santo Domingo maintains control throughout the country.

4 National Potable Water and Sanitation Institute (INAPA)

The National Potable Water and Sanitation Institute (INAPA Spanish acronym) is currently "in charge of" 363 aqueducts that produce 36,982,595 cubic meters of water a year (Rodriguez, 2008). Of these 108 serve 343 urban localities and 255 serve 764 rural localities (Rodriguez, 2008). The institutional history of INAPA and water and sanitation sector has been influenced greatly by political cycles (see Figure 7 for an overview).

4.1 General Institutional History

4.1.1 Early Years: Trujillo "Mi política de Agua"

The first coordinated effort to improve the water and sanitation situation in the Dominican Republic was undertaken by Dictator Rafael Leonidas Trujillo after a natural disaster destroyed much of the country's infrastructure. Trujillo won favor with the Dominican people with his rapid response to the disaster caused by hurricane San Zenon that devastated Santo Domingo on September 3rd, 1930. The fifth deadliest hurricane on record, it killed over 8,000 and left the capital city in complete ruins.

As a part of the reconstruction effort, Trujillo began what he called "*Mi politica de agua"* which means "my water politic." Although infamous for violence and an insatiable desire for power, *El Jefe* (the boss) was very efficient in executing projects he deemed worthy. World War II put water and sanitation projects on hold, but between 1945 and 1953 *El Jefe* built 265 rural systems that utilized wind mill pumps to extract groundwater to a small tank serviced by a public tap stand. For many rural people this reaffirmed their conviction in their *caudillo,* which is a Spanish term that means authoritarian strongman ruler. Water and sanitation projects in the DR would be overseen by Trujillo for 31 years, during which time "John Pipe," an American contractor was hired to build aqueducts in the urban cities (Rodriguez, 2008). From 1932 until 1955 *mi política de agua* was operated from a centralized platform by the General Direction of Aqueducts of the Secretary of Promotion, Public Works, and Irrigation. In 1955 the coordination was delegated to local municipalities, but by the end of Trujillo's dictatorship, marked by his assassination 1961, the sector was in complete disarray (Abreu, 2005).

4.1.2 Bureaucratic Era

The end of Trujillo's reign marked the return to a centralized model that was expanded beyond the pre-1955 platform, creating a new "bureaucratic era" in rural water and sanitation. The bureaucratic era began with a tug-of-war over jurisdiction in water and sanitation provision amongst governmental organizations. Under the government of Joaquin Balaguer a plan was put in place to create a governmental entity to manage the water and sanitation needs throughout the country. The National Institute of Potable Water and Sanitation (INAPA acronym in Spanish) was formally created on August 11, 1962 with the signing of Law 5994 (Number 86-80), and with Number 87-46 of March 24, 1963, INAPA was given the administrative power over the provision of water and sanitation throughout the Dominican Republic.

Later, in 1964, congress passed Law 151 which transferred authority over rural water and sanitation initiatives from INAPA to the Secretary of the State of Public Health and Social Assistance (SESPAS acronym in Spanish). This created the National Service of Rural Aqueducts, or SNAR plan. INAPA was further relegated with passage of Law 701 in 1965 that created the Secretary of Hydraulic Resources within the National Institute of Hydraulic Resources. These laws, which stripped power from INAPA, were effectively repealed later in 1965 and 1966 when INAPA was "newly reinstated" as principal and autonomous actor in the provision of water throughout the country. This included the transfer of "all functions, personnel, equipment, and facilities" (Law 24, Art 2, Paragraph 1) of SNAR to INAPA, giving them sole operation and maintenance authority of municipal aqueducts.

A legacy of SNAR was the institutionalization of domicile connections, which were promoted and become widely expected around the country. In 1978, sanitation systems were included in this transfer of jurisdiction to INAPA (Rodriguez, 2008). The changes in political and administrative structure that occurred during the 50s, 60s, and

70s foreshadowed the disorganization that has become the hallmark of the water and sanitation sector in the DR.

The National Plan for Rural Aqueducts, or PLANAR (acronym in Spanish), is credited as the beginning of the community management model in the Dominican Republic. Beginning in 1966, the objective was to construct 650 rural aqueducts with household connections in communities with 500 people or less. It included the election of community water committees that were charged with the operation and maintenance of the aqueducts after the completion of the construction. Committee members were elected every two years in assemblies of the system "users" and were selected from the "natural leaders" of the community. To fund PLANAR the government along with the International Development Bank (IDB), created the *Fundo Rotatorio* (rotary fund), whereby the government and IDB contributed money to the fund to be loaned to the community at a low interest rate (1.24-5%). Money was then collected by the community leaders on the water committee, and 53% this money was used for operation and maintenance purposes, with the other 47% used to amortize the loan (40%) or as an "interest payment" (60%) to cover INAPA's operating costs at the zonal and central levels. The money used for the principal went into the revolving fund (hence the "rotary").

PLANAR projects were identified with information from the 1960 federal census and were based upon four criteria:

1) Availability of laborers in the community
2) Local availability of construction materials (gravel, sand, rock, and wood)
3) Right of way permission and land grants
4) Ability to be "self-financed" over the long term

The first phase of PLANAR was executed in its totality with 76 systems serving 114 communities. However, there were many difficulties because of the "demands in the application to the financial resources associated with the loaned money from IDB" (INAPA, 2000).

In the second phase, PLANAR II, an "executive unit" was created to facilitate the disbursement of loan money. In addition, community participation in the form of manual labor was switched from remunerated to voluntary. This plan was also completed but with difficulty due to the lack of organization and training of the community participants. Only 73 systems were built serving 158 communities.

The final phase, PLANAR III, was initiated but never completed. Only 16 systems were built for 55 rural communities. It was prematurely terminated because IDB demanded that all previous systems built under PLANAR I and II be "optimally operating" before new funds would be dispersed. The systems were not operating for lack of appropriated maintenance and, as a result INAPA initiated an aqueduct improvement project (PROMAE).

The failures from PLANAR I, II, and III offer insights into the challenges in RWS today. After PLANAR I, it was decided that ten percent of the total costs were to be in the form of community contributions, specifically in kind labor. This caused friction as workers felt entitled to payment from the government as word spread that community laborers in previous projects were paid (under PLANAR I). Initially, under PLANAR I community labors were given food provisions from the World Food Program and later began to feel entitlement, so when the provisions were not available workers would strike.

Another problem was the lack of community participation in all levels of the project, most importantly decision making. In addition, the "rotary fund" concept never came to fruition as communities never generated sufficient funds to cover the loan costs, much less operation and maintenance costs of their system. The current sub-director in INAPA Marcos Rodriguez is an expert on the history of INAPA and is currently writing a book about the history of the water and sanitation sector in the DR. He summarized the failures of PLANAR by noting the tendency for dependence, stating that as the role INAPA played increased, the role of the community decreased (Rodriguez, interview 5/6/08).

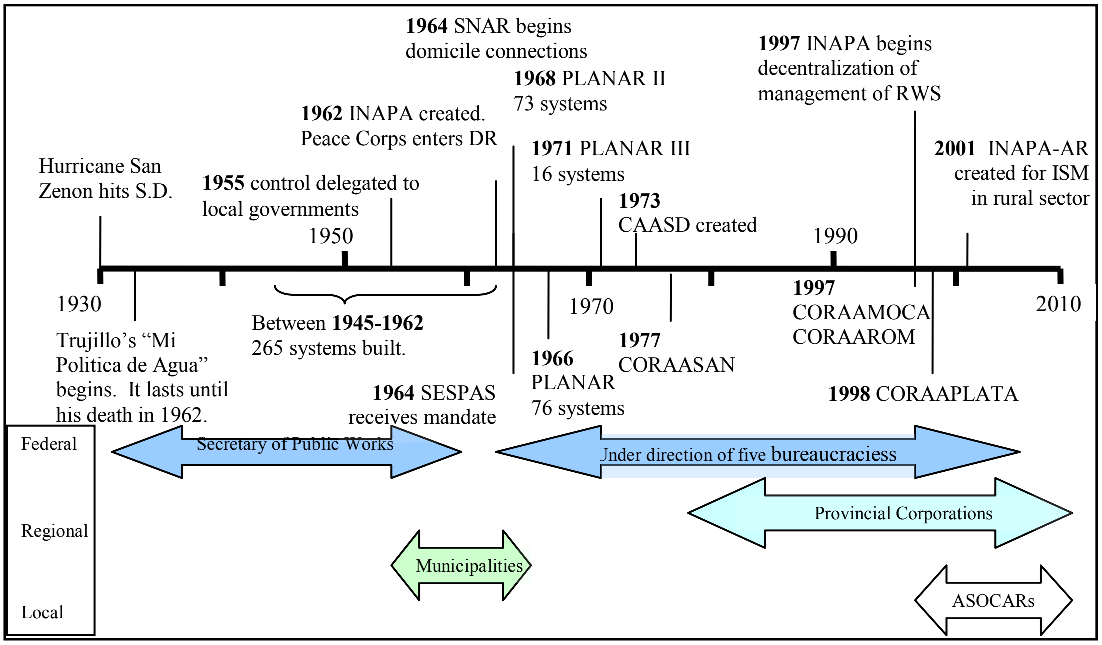

Figure 7: Timeline of the Institutional History of the National Institute of Potable Water and Sanitation (INAPA). The horizontal arrows represent the different eras (with the controlling organization(s) listed in the arrow) and their vertical position corresponds to the organizational level (upper is federal, middle is regional, bottom is local).

4.1.3 Decentralization

Until 1997 INAPA was in charge of the all rural systems in the country, with each community (ideally) collecting funds to cover small operation and maintenance projects and excess monies deposited in INAPA's slush fund. As the merits of management decentralization gained ground in the 1990s the United States Agency for International Development (USAID), through the Environmental Health Project (EHP), worked with INAPA to develop a strategic plan for decentralization. USAID worked "to provide guidance in the design and establishment of support mechanisms that contribute to a greater capacity for sustained community management of rural systems"(Lockwood, 2002). USAID consultants concluded that INAPA needed to restructure operations to include a specific division in charge of the decentralization and support of RWS. In addition to outlining specific ISM of this entity, the consultants designed a pilot project for testing the decentralization strategies in the provinces of Hato Mayor and El Seybo in the eastern part of the DR. The goal of the pilot project was to refine the mechanisms to increase cost effectiveness of service provision, improve sector planning and governance, promote cost recovery, and ensure compliance with environmental regulation (Lockwood, 2002). The specific activities being carried out in the decentralization process are based on the Total Community Participation (TCP) model.

The goal of Total Community Participation is for the community to exercise control over the development of their water and sanitation system. It has three basic components: responsibility, authority, and control, and to reach these goals the model includes capacity building activities in: basic accounting, hygiene behavior change, basic plumbing, community organization, environmental "sensibility," and disaster mitigation (INAPA, 2006). TCP has, as a special emphasis, gender equality, which is a "key element in water projects, as women are the ones who suffer from the absence [of water] and those most interested in guaranteeing the sustainability [of water resources]" (INAPA, 2006).

4.2 Management Model: ASOCAR

In the management decentralization process the rural aqueducts division of INAPA (INAPA-AR) creates a community management body that they call an association of a rural aqueduct (ASOCAR is the Spanish acronym). The organic structure of INAPA-AR is shown in Figure 8. The self declared role of INAPA-AR is to serve as manager and director of all the rural systems in the country (those outside the jurisdiction of INAPA and the CORAAs), normalize the criteria and design techniques, technically assess the work of NGO built systems, and supervise and monitor the ASOCARs. Only in absence of other institutions does INAPA-AR construct new systems, promote TCP, and organize ASOCARs. Guaranteeing the sustainability is the expressed responsibility of the community.

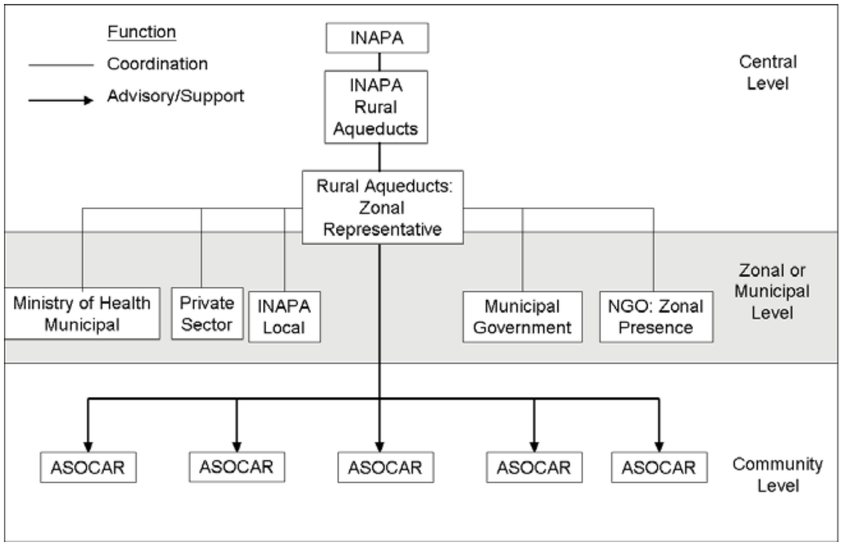

Figure 8: Organic Structure of the National Institute of Potable Water and Sanitation (INAPA) Rural Aqueducts Division. Currently there are three "zonal representatives" working in INAPA-AR. The remainder work out of the Santo Domingo office (INAPA, 2008)

Under Law # 5994-62 and Amendment 8955-63, the role of the ASCOAR is to administer, operate, and maintain the system providing potable water to the community. In addition, they are to help INAPA explain and divulge information when necessary, and protect the infrastructure, charge a user fee, participate in other programs, and carry out internal elections annually. In turn INAPA is responsible for supervising and monitoring the ASOCAR; auditing accounts, monitoring water quality, helping the ASOCAR incorporate, and educating them on health behavior change. It is important to note that INAPA delegates the administration of the water system to the ASOCAR, and under Law 122-05 the ASOCAR can obtain legal some legal rights to enforce rules within the community, but the state maintains ownership of the system. Incorporation is the last phase in the formation and training process.

4.2.1 Formation

Systems that go through this decentralization process are built by INAPA (or INAPA contracted entities) or are designed and built by outside organizations (NGOs, GOs, private companies, etc) and later turned over to INAPA-AR for decentralization.

For communities where INAPA is the primary actor the process that is executed follows these steps:

STEP 1: Community Identification Process- Community formally solicits project and feasibility study and planning process begin. Communities with easy access, financial resources, and commitments to grant land easements for construction works are preferred (INAPA, 2000).

STEP 2: Community Organization

1) Creation of a "*Comité Gestor"* (Management Committee) from community leaders and future users, who will participate in the planning and construction of the system, protection of materials, supervision of construction, donation of lands, internal transport of materials, and serve as the interface between the contractor and the community. The process of forming an ASOCAR should take approximately 3 weeks (INAPA, 2008). A census is conducted and a formal action plan is developed.

2) The contractor is mandated with training two plumbing helpers, elected by the *Comité Gestor*, who serve as assistants during construction and, upon completion of the main line, install lateral connections to each home.

3) With oversight and guidance from INAPA regional supervisors, the community meets to develop bylaws and elect a formal Community Water Association (ASOCAR). This committee is composed of a minimum of 5 people but usually is made up of:

1) President
2) Vice President
3) Treasurer
4) Secretary
5) Vocal (announce meetings)
6) Vocal (announce meetings)
7) Fiscal (audit accounting)

To be considered for a position in the ASOCAR, the person must be a member of the community, be up-to-date with tariff payments, be older than 18 years, know how to read and write, and be of Dominican nationality. There is also a clause that prohibits two members from being of familial relations (2^{nd} degree). These requirements reveal a bias towards working in the more developed regions. Other requirements that are listed in the contractual agreement between the ASOCAR and INAPA-AR are:

- 2 year terms
- 2 re-elections to the same job
- Miss no more than 3 meetings consecutive
- Change 50% of the ASOCAR yearly
- Miss no more than 5 meetings (total) without valid excuse

4) After the ASOCAR is elected the amounts of the community's financial commitments are established. These commitments including the initial "water right" **contract** (established by INAPA) that usually paid before receiving the service or shortly thereafter and the periodic **tariff** (usually paid on a monthly basis) for the operation and maintenance costs.

Upon completion of the system, INAPA formally transfers responsibility to the community for the control, operation, and maintenance, and afterwards the process of incorporation can begin. Incorporation allows the ASOCAR to be recognized as a non-profit organization under Law 122-2005, giving them legal status and the benefits that entails.

The incorporation process requires that each ASOCAR have elaborated statutes which include the duties to "administrate, operate, and maintain [the system] in good condition in agreement with the norms and policies that INAPA dictates" (INAPA, 2008). Finally the ASOCAR enters into the following and evaluation phase whereby an INAPA supervisor makes periodic visits to monitor the status of CM. This period should last up to two years.

4.2.2 Training

The training regime described in the INAPA informational materials includes basic accounting, hygiene behavior change, basic plumbing, community organization, and disaster mitigation. It is unclear to the author how extensive the training is; after working with INAPA for approximately 4 months the author still had not witnessed a formalized training program. All time spent in the field was dedicated to revision, auditing, and general follow-up activities. Through a special agreement the Spanish Agency for International Development (AECI) has conducted a more comprehensive training program that included a grade school education campaign on the environment, reforestation, water use, and farming practices. AECI also has done reforestation projects in the watersheds of various communities.

5 Peace Corps Dominican Republic

In 1960, then Senator John F. Kennedy gave a speech to students at the University of Michigan challenging them to promote peace, friendship and the development of impoverished nations around the world. This speech is credited as the foundation for the creation of the Peace Corps. Volunteers arrived in Ghana a year later, and to date more than 195,000 American men and women have responded to JFK's challenge by serving in 139 countries. Today 7,876 volunteers in seventy-six countries serve in education, health and HIV/AIDS, business, environment, youth, agriculture, and other areas (www.peacecorps.gov Retrieved on 12/8/08). The second country to receive Peace Corps Volunteers (PCVs) was the Dominican Republic, when in July 1962 twenty volunteers began their two-year commitment.

Over 4,000 volunteers have served in the DR, and currently 150 are working "[to assist] organizations and communities in implementing sustainable projects that will improve the quality of life of disadvantaged Dominicans." (http://dominican.peacecorps.gov Retrieved on 12/8/08) Volunteers work in seven project areas: Community Economic Development, Community Environmental Development, Healthy Environment, Healthy Communities, Information and Communication Technology Education, Basic and Special Education, and Youth, Families, and Communities Development.

5.1 Healthy Environment Program

5.1.1 Background

During the final year of the International Drinking Water Supply and Sanitation Decade (1980-1990), PCDR started the Healthy Environment Program. PC involvement in the water and sanitation sector was motivated by the same concern expressed by the United Nations years earlier- a large part of the population does not have "reasonable access to safe and ample water supplies [or] adequate sanitation facilities" (UN, 1980).

In the Dominican Republic in the 70s and 80s, rapid population growth, massive migration to urban areas, and increasing numbers of people living in poverty resulted in serious deficiencies in the coverage and quality of water and sanitation services (Leon, 2006). The focus of the Healthy Environment Program is to increase the availability of drinkable water and sanitation facilities through the construction of rural water systems and latrines, organize and train communities for the longer term operation and maintenance of these health interventions, and design/implement hygiene promotion education tools with the recipients of the aforementioned facilities. Volunteers work with water providers and user communities "to examine the array of technologies available to remedy the particular problem - such as the construction or rehabilitation of water facilities - and to promote improved hygiene practices" (Peace Corps, 2008).

The Healthy Environment Program (HE) has three stated goals (for a complete listing of the goals and objectives see Appendix A.1). The first goal is for low-income families in rural areas to improve their water and sanitation infrastructure which will decrease the transmission of water related diseases. This is done through the construction of community gravity-fed rural water systems and secondary projects such as familial ventilated improved pit latrines. The proper construction of these health interventions improves and protects water sources from biological pathogens (protozoa, bacteria, viruses, and intestinal parasites) and chemical contaminant (agricultural pesticides, herbicides, and fertilizers) that may come from point and/or nonpoint sources. Community infrastructure development in the form of aqueducts and latrines is an import first step towards creating a healthy environment, but another equally important component is that of education for behavior change.

The second goal of the HE program is that rural low-income families will adopt improved sanitation and health practices through educational activities. During volunteer pre-service training and throughout their service, emphasis is continually placed on promotion of basic hygiene, adequate sanitation, and appropriate treatment, handling, and storage of water. Peace Corps volunteers "encourage people to adopt behaviors that promote good health, prevent illness, cure disease, and facilitate rehabilitation" (Peace Corps, 2008). To ensure objectives are reached, educational talks are complemented by house visits conducted by community health promoters. Volunteers identify community leaders, with a gender empowerment focus, with the ability to serve as models and carry the public health messages to the household level. It is of paramount importance to ensure the participation of women who are the primary users of water and sanitation project facilities, an idea which is widely promoted and accepted in the WAS field (Wakemen (1995), Mathews (2005), and Jimenez *et* al, (2006)).

The third goal of the HE program is to cultivate initiative and leadership within the community. "Community participation is integral to success of the HE Program" (Leon, 2000) and therefore the third goal outlines the necessity for community members to take an active role in all phases of the project: needs identification and assessment, feasibility study, design, implementation, and follow-up. PCDR has adopted a training model that encourages such leadership, through the conception of an active and effective water committee.

Overall the purposes of the HE program are to convince the local people that clean water and proper sanitation improve their health and to teach them how to have a positive impact with that knowledge.

The criteria for soliciting a PCV from the Healthy Environments sector is

1) Technically Feasible Source

- Source can provide at least 20 gallons/person/day
- Sufficient elevation head for gravity fed design
- Water quality is acceptable (potential for adequate source protection)

2) Community Organization

- An oversight committee exists
- Capability/willingness to supply in kind labor, land, and locally available materials (sand, gravel, wood, etc)

-Willingness to host and guide volunteer throughout the process

Peace Corps focuses on gravity-fed systems which have a definite advantages over other systems: lower capital cost, technically simple to operate and maintain, low cost of operation and maintenance, and, frequently, 24-hour service. Pumps are only used under extenuating circumstances due to the belief that such systems require specialized knowledge and resources (financial and material) that often fall beyond the scope of the communities' capacity. Since 1990 only 5 systems (4%) have been built using pumps.

5.1.2 Peace Corps Niche

The niche that Peace Corps fills is definite and important. The language in the guidelines and requirements documents obtained from INAPA demonstrates that it is not inclined to work in the most isolated of areas due to the high costs of a centralized project planning and implementation structure. INAPA's listed maximum forecasted cost to proceed with construction is 200 USD/person. Peace Corps is able to work in areas that INAPA cannot because the costs are external to the project; the only actual monetary costs are materials. The costs of the volunteer are covered through the volunteer salary (paid by the US government) and the community provides the in-kind labor, donates land, and often provides equipment and materials for the construction. Data is insufficient to calculate what the actual total Peace Corps project costs are but the author's estimates range between 2.5 to 3 times the costs of materials (See Figure 9).

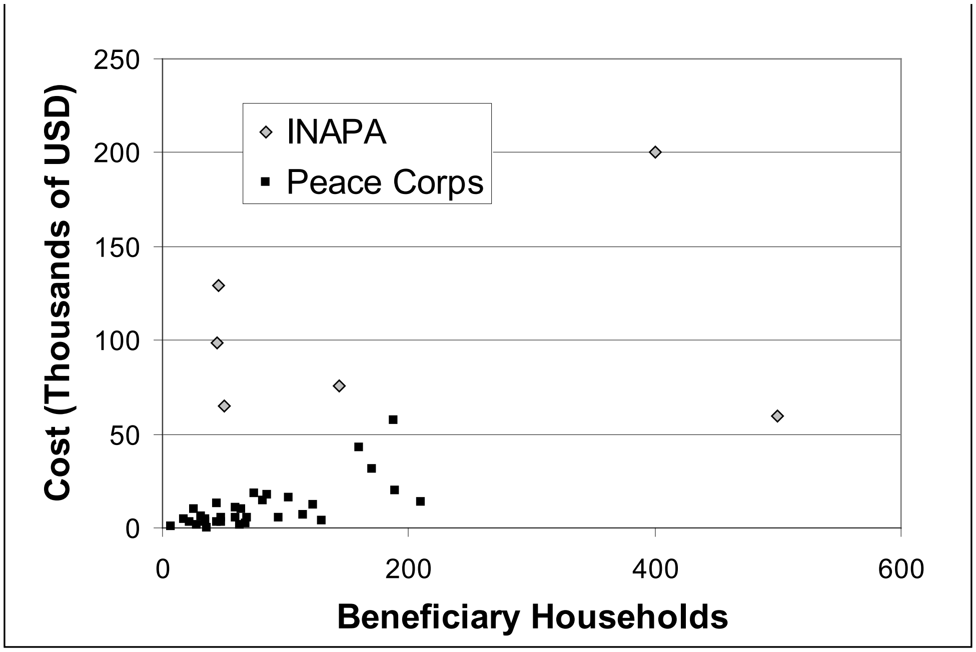

Figure 9: Cost Comparison between INAPA and Peace Corps RWS. Peace Corps data represents total materials cost and does not include the value of in kind contributions or the engineering/construction management value provided by the volunteer. However data from similar studies in the Dominican Republic (USAID, 2006) reflects these trends in cost between INAPA systems (usually built by private contractors) and Non-governmental organizations (or in this case the Peace Corps).

5.2 Management Model: "La Directiva"

The Peace Corps water committee model, usually called "*La Directiva*" (the directorate) is very similar to the INAPA ASOCAR model and most water committee community management organizations. Typical roles include:

- Administer system and facilitate community decisions
- Control and audit finances
- Inform community and liaise with government and civil society
- Ensure flow of benefits and proper system operation
- Oversee technicians; coordinate maintenance, replacement of parts, and system expansion.

5.2.1 Formation

The *Directivas* established by Peace Corps Volunteers are usually composed of 7 people elected from the community. There are no specific requirements to be elected as a member of the directorate, and the make-up is dependent on the community in question. *Directivas* usually have a president, secretary, treasurer, plumber, and a number of "vocals" that announce meetings to the community.

Peace Corps management model is based on the Principles of Participatory Analysis for Community Action (PACA), whereby the volunteer works with the community through all stages of the project: planning and design, implementation, and monitoring. Theoretically the community has identified the need for the system and solicited the volunteer. When the volunteer arrives, a three-month orientation period occurs. During this time the volunteer, together with the *Directiva* and community leaders, conducts a feasibility study that includes:

1) A community-wide census to establish baseline health statistics and water demand figures
2) Water resource assessment (quantity/quality, technical feasibility, security, etc)
3) Topographic study of the terrain and community

This information is compiled, analyzed, and presented at a 3 day workshop attended by volunteers in the water sector and a representative of each community after 3 months in site. During and after the feasibility study period the volunteers work with the elected committee through a series of training exercises to develop the skills necessary to execute the project and carry out long term operation and maintenance. See Appendix A.1 for a diagram of committee structure and responsibilities.

5.2.2 Training

Unlike INAPA, each volunteer has complete control over the training curriculum and how it is implemented. The most common method is informal *charlas* (talks) using didactic materials or actual hands-on experience, and very little formal classroom setting exercises are used as illiteracy rates are high (over 75% in the community where the author lived). Training exercises usually include a community map, seasonal calendar of the important dates and agricultural seasons, and a daily calendar of chores and activities. These activities serve a dual purpose; they are fact finding exercise for the volunteer to acquaint themselves with the area and culture, but also the dialog between the volunteer and community and within the community is opened and the planning process begins. Later more specific project related issues are tackled (work scheduling, land easements, by-laws, regulations, tariffs, etc).

One of the benefits of the Peace Corps methodology is the issue of access. The volunteer develops rapport that can be beneficial for identifying natural leaders in the group, incorporating marginalized populations within the community (by leveraging their status), and ensuring all interest groups and perspectives are represented, tasks that a development worker living outside the community might not be able to do.

6 Data Collection Methods

This research evaluates the efficacy of community management of systems constructed by both Peace Corps (PC) and the National Institute of Potable Water and Sanitation (INAPA). This evaluation is conducted in order to improved community management training models and post construction support (similar to those discussed previously in Chapters 3 and 4) and reflects literary research and data collection over the course of the past three years. To complete this evaluation it was necessary to examine both successes and failures in community management of water systems; the most common reasons for system mismanagement, deterioration, and/or component failure and the characteristics or conditions connected with success are examined. In conclusion, changes to respective training models and suggestions for components of an ideal training model are then made.

While several different data collection methods are used in applied social investigation in rural areas, one of the most widely accepted methodologies for the design, evaluation, and improvement of development programs is Participatory Rural Appraisal (PRA), a type of Rapid Rural Appraisal (RRA). The basis for PRA originates in the early 1980's; this anthropologically based approach aims to incorporate the knowledge and opinions of rural inhabitants in the planning and management of development projects and programs. PRA is a type of Rapid Assessment Procedure which descends from the work of educational theorist Paulo Freire, who laid the framework for the idea of *critical pedagogy*. The relative importance of critical pedagogy is the inclusion of the subject into the investigative process or the promotion of *critical consciousness* through participatory processes, which is the central tenant of PRA (Freire, 1970). Originally developed by the United Nations University Research Program to obtain high quality health data in a condensed timeframe, these PRA approaches:

> "Investigate household and individual health-related behaviours within their complex, rational matrix of personal, organizational, and social realities. [PRA

approaches] search for opinions and attitudes, behavior, and motivations of both the clients of development programmes and also those who deliver services. These tools lead to the type of understanding of both groups that is essential both to planning and evaluating health, nutrition and other social development programmes" (Scrimshaw, 1992).

The data collection methods used in this research are based on PRA approaches and reflect the standards used to obtain a better understanding of the performance of community-managed rural water (Whittington, 2008, and USAID 2006). The following sections explain the specific research techniques utilized.

6.1 Standardization of Research Techniques

The basis for PRA is that one data collection approach alone cannot ascertain a complete picture and therefore it is necessary to triangulate data by using multiple approaches (Yin, 2003). Possible approaches include: database, archive and literature reviews, participant and non-participant observation, focus group, and key informant interviews which, when combined, can produce highly detailed data leading to accurate results. The methodological approach to this research is similar to the data collection techniques used for a "field situation analysis" conducted by the United States Agency for International Development. The final report, "Evaluation of the Strategy to Increase Potable Water Access and Sanitation in Rural Areas in the Dominican Republic" (2006) assesses the strategy and advances of the model used in USAID's pilot project (conducted with INAPA) in the province of Hato Mayor. The methodologies described in the following sections are consistent with accepted standards utilized by USAID and others (Whittington, 2008).

6.1.1 Secondary Data Analysis

There has been a large effort to collect and organize data on the existing RWS in the Dominican Republic, by USAID, INAPA, Peace Corps, and other organizations.

For example, a third year Peace Corps Volunteer conducted a review of all Peace Corps RWS built until 2002 (Schmidt, 2002). In 2006 this information, along with piecemeal additional data on PC systems constructed after the 2002 publication, was compiled into a database to be utilized for a series of three Water Congresses held between February and March 2007. The results of the Water Congresses together with the 2002 report, database, and a random selection of volunteer project reports compose the institutional memory of the PC Healthy Environments Program. These documents were used during the logistical planning phases of this research and also again in the data analysis phase as a temporal comparison; by comparing existing data with data collected during the community visits trends could be identified.

Due to the organizational scale of INAPA, the information at INAPA was much more plentiful, however without organization. Invaluable information and direction was obtained through informal conversation with community members, volunteers, and INAPA and PC employees. This information many times provided new direction to the research, creating a snowball effect of ideas. It was very difficult to maintain a practical scope to the type of data and number of sources. It often seemed logical to include another data set, question on a survey, or community but it was necessary to limit the scope in order to maintain a high level of quality. The literary research, conversations, and informational interviews helped to give the research direction and limit the scope.

6.1.2 Observation (Participant and Non-participant)

Careful attention to details of events, behaviors, and circumstances is a valuable way to collect data. The data collection included community transect-walks to triangulate information given in the conversations, interviews and surveys with first hand experience. This was most useful for confirming objective data like latrine coverage, level of service, tank size, etc. It was also useful to see how communities partitioned water usage between domestic, agricultural, livestock, and washing. Often community members will not admit to using water for irrigational purposes but cursory observation of the greenery within close proximity of the tap stand (within 100 feet, the longest garden hose commonly available at hardware stores) can verify their responses.

6.1.3 Focus Group/Key Informant Interviews

The most detailed field data collected came from focus group and key informant interviews. Exploratory group sessions with community management groups (water committees) were used to gather qualitative as well as quantitative data. In addition, key informants (community plumbers and operators, PC volunteers, and INAPA regional supervisors) were also interviewed to triangulate data gathered from other sources. The forms used for data collection (referred to in this report as "surveys") and approved by the Institutional Human Subjects Committee at Michigan Technological University are included in the Appendix (A.2-A.5).

6.1.4 Household Surveys

Finally surveys with community beneficiaries were conducted to obtain public sentiments about the service provision. A random sample of households was used to obtain a baseline of community opinions and therefore verify focus group and key informant information. Surveys were conducted using ten percent of households [chosen at random] with access to water from the system administered by the community management organizations. The survey consists of 20 questions with binary ("yes" or "no") response and one quantitative response question (see the Appendix for the different Data Collection Forms.)

The total number of houses to survey was determined by rounding the product of sampling interval (10 houses) and the total number of houses benefiting from the water system. A random number function was used to determine the random start number house. The random start number was calculated by multiplying the sample interval (10 houses) by a random number between 0 and 1 inclusive obtained from a graphing calculator function. Adding multiples of the sampling interval to the random start number gave the number of the houses which would be surveyed. The houses were numbered with the first house encountered in the community being 1. These simple analytic procedures are commonly used for cluster sampling (see Section 1.2.2).

6.1.5 Formal versus Informal Interviews

Due to literacy levels (78.2% national) and, in addition, reading comprehension issues (problem of functioning illiterates) informal, yet in-depth, interviews were chosen as the preferable method over structured formal interviews (ONE, 2002). During the focus group surveys short answer as well as open ended questions were asked by the researcher(s) to individuals and community groups following a general outline, but also incorporating additional topics when necessary and relevant. In addition to the multiple choice and fill in the blank parts on the survey forms (found in Appendix A.2-A.5) field notes were taken as a supplement and later used to identify patterns and reoccurring themes.

6.2 Cultural Sensitivity in the Dominican Republic

During pre-service training all PCVs are provided instructions on the "Do's and Do Nots" of census taking in the DR and on the design of survey questions for cultural compatibility. Many of these instructions are considered standard operating procedures in the social sciences such as not using leading questions or suggesting responses (for non multiple choice questions). With regard to other more latent issues, the experience the author of this report accrued during three separate community surveys (over 150 households in total) was incredibly valuable to the research. These surveys were conducted in one of the poorest areas of the Dominican Republic, the border province of Elías Piña , where literacy rates are incredibly low (48.1% in the municipality of Juan Santiago where the author lived for two years) ONE (2002).

One such issue that the author learned to avoid is "notebook intimidation" whereby respondents in very rural areas might become nervous about having a *gringo* (foreigner) asking them questions (especially personal questions about family health, or income). This can be avoided by beginning the conversation with small talk (weather, crops, or family life) and the transitioning to the survey. The object is to obtain *confianza* or trust with the respondent. Notebook intimidation was less of a problem in communities with PC systems as a PCV lived in the site for two years and conducted a community diagnostic census. In these communities it was beneficial to ask respondents about their experiences with their "American friend" that allowed them to relax and the census taker to gain their *confianza*. For INAPA systems, in order to minimize the notebook intimidation trained INAPA supervisors with experience in the community (and in censing) administered the household surveys.

When possible, communities were notified in advance by the author or INAPA personnel to facilitate a smooth meeting, to promote a reasonably punctual start time, and to ensure all necessary documentation was present. These benefits outweigh any potential bias created by the advance notice, such as the belief that the advance notice might motivate the water committee to put thing in order (collect tariffs, organize accounting books, or conduct community meetings). It is difficult to make years of disorganization appear organized overnight and even more difficult to change community behaviors. It was common for water committees to openly reveal their motives to leverage the research visit as a catalyst to "animate" the community to put things in order after the encounter. Also, at no time did a community exhibit signs of hastily acting to misrepresent the actual service status or management.

6.3 Field Procedures

To ensure smooth execution of the field research and limit expenses (travel, lodging, etc) whenever possible INAPA and PC resources were leveraged. INAPA surveys were conducted in coordination with INAPA-AR workdays Monday thru Friday 7AM to 5PM and scheduling and notification was left up to INAPA supervisors. The network of over 150 PCVs throughout the country was leveraged to notify communities and schedule meetings.

Seven INAPA regional supervisors from the "Social Promotions" department, seven PCVs, and one Dominican counterpart (to a PCV) assisted by executing household surveys. Although all assistants were highly educated (12 of 15 hold bachelor's degree) and/or had many years of experience in RRA in the DR, the research techniques were reviewed with each individual assistant including the human subject research requirements and regulations surrounding the informed consent. Each person observed various household surveys with the author before proceeding on their own. The yes/no response structure of the household surveys combined with the qualifications of the fifteen assistants ensure the consistency of their methods and accuracy of the data. Surveying was conducted between November 6, 2008 and March 7, 2009. For a complete listing of the communities and the assistants who helped administer the surveys and interviews see Appendix A.2-A.5.

All participants in the key informant, focus group, and household surveys were at least 18 years of age, were read the informed consent declaration, and consented orally to participate in the research. This is consistent with the research protocol reviewed and approved by the Institutional Review Board (M0420) at Michigan Technological University. See the Appendix for all survey forms (A.2-A.5) and the oral consent form (A.6).

6.4 Limitations

The research methodology collected both qualitative and quantitative data. There is ongoing debate regarding the reliability (the representativeness or replicability of data) and validity of quantitative versus qualitative research methodologies. Analyses of different methodologies can be found elsewhere and is outside the scope of this thesis. Due to limited time and resources it was necessary to design the field activities (committee interviews, community surveys, key informant interviews, and observation activities) so that they could be completed in the allotted timeframe in each community.

Since the data collection was conducted in orchestration with INAPA-AR and in order to maintain consistency with PC surveys, the level of detail of the PRA approaches was dictated by the INAPA site visits. The social promotions division at INAPA-AR is located in Santo Domingo and nearly all trips were day trips leaving from the capital. Therefore it was necessary to reach the remote communities (sometimes as far away as 8 hours roundtrip) and return to the capital in the same day (with exception of one overnight trip). Therefore the time dedicated to data collection within the community was limited to three or four hours maximum.

6.5 Data

6.5.1 RWS Sample Size

Currently 86.4 percent of the population in rural areas in the Dominican Republic is reported to have access to an improved source, such as a protected spring, covered well, or bottled (ENDESA, 2007). Yet it is unknown exactly how many RWS projects are operating in the DR today. A database was created in 2002 by USAID consultant Eric Johnson, as a part of a strategic decentralization of RWS plan. The database was meant to serve as an information management tool, to provide support to communities, allow for timely response during emergency situations, and organize data for ease of analysis. Despite Johnson's work, the database was never effectively utilized, and when INAPA failed to create an internal file sharing system, the only copy of the database that INAPA had was lost when the computer it was saved on crashed. Upon the author's investigation the file was eventually recovered from a previous employee. INAPA/AR, the governmental entity responsible for providing and supervising water services in rural areas, does not know exactly how many RWS exist or are actually functioning.

The recovered database file identifies 1,847 RWS systems created before 2002 but in September 2001 the director of INAPA/AR cited a figure of over 2,500 "projects" serving approximately 1.5 million people (Lockwood, 2002). It has been estimated that the total number of RWS systems added each year is around 110, since NGOs and bilateral organizations alone constructed 1,500 between 1991 and 2001 (Lockwood, 2001). Therefore, a probable range of RWS in the DR today is between 2,200 and 3,000 systems. These systems range from hand pumps or windmills pumping water to a small tank serviced by a single public tap, to gravity fed or solar powered electric pump systems with complicated distribution networks and multiple household connections. Also included in that statistic are improved wells, boreholes with hand pumps, windmills, and other simple point source supply projects.

Due to their very nature, hand pumps and windmill setups require a lower level of operation and maintenance; historically (in the DR) such projects have not included the creation of a community management entity, and hence hand pumps and windmills are excluded from this research. Also excluded are rainwater collections systems which are household-level supply systems and therefore do not require community management organization. In conclusion, for this research, rural water supply (RWS) systems include all systems, gravity fed or mechanically assisted, that provide water for domestic use, which is consistent with the public expectations of a high [household] service level (Lockwood, 2001).

Many of the RWS in the DR were constructed without a community participation (CP) strategy and/or do not have any community management (CM) component. Since the purpose of this research is to evaluate CM of RWS in the Dominican Republic, only systems with strategic CM training models were included. As the principal actor and legally recognized entity in RWS, this research focuses on INAPA/AR systems, some of which were constructed by INAPA/AR and others that were constructed by other actors (governmental, civil society, others) who then turned over CM training and education to INAPA/AR. For comparison, the Peace Corps' CM training model was identified, to provide the prospective of the a more "grassroots" level system design and training as the volunteer lives and works with the community for a period of two years. The Peace Corps model has been used in over 122 RWS with 12 projects currently underway.

To establish a baseline and acceptable scope (i.e. sample frame) for the analysis and to ensure maximum comparability among the sample communities, a set of requirements was developed to identify the total quantity of RWS systems to be considered during sample size calculation and final sample selection. It was first necessary to define what constitutes a rural area to eliminate extreme variability which might arise from demographic, economic, or political differences among seemingly "rural" communities. Unfortunately there are not homogenous criteria used to differentiate between rural and urban areas. The Dominican government, like the United Nations Populations Division, defines urban populations as people whom reside in al and district heads of the country that are distinguished through by qualitative means and therefore the rural population is the balance.

In an effort to establish a quantitative threshold for distinguishing between rural and urban communities the functional definitions of "rural" used by various different countries in Latin America were investigated. Some countries use population density, sector incomes, or distances from urban centers factors which are difficult or inconvenient to measure. A threshold was extrapolated using the median value expressed in the Table 8. For purposes of this report rural is defined as a community with total aggregate population less than 2,000 inhabitants. The political division in the DR that most often corresponds to this threshold is a *session* or *paraje,* both of which are beneath the municipal level.

Table 8: Definitions of "rurality" used in Latin America from (PNUD, 2007) translated to english.

Variable	Country	Threshold
Residences outside of urban areas (Defined administratively or by census)	Columbia, Costa Rica, Ecuador, El Salvador, Guatemala, Paraguay, **Dominican Republic**, Uruguay	N/A
Population	Argentina, Bolivia	Up to 2,000 people
	Mexico, Peru	Up to 2,500 people
Population and administrative definition	Peru	Up to 100 contiguous homes, not inside a municipality
According to political seat and occupation of population	Chile	Up to 1,000 people or 2,000 if half work in agriculture
# of inhabitants and inexistence/unavailability of certain services	Cuba	Up to 500 or 2000 if inhabitants are involved in agricultural sector work
	Nicaragua	Up to 1000 people without services
	Panama	Up to 1,500 people without services
	Honduras	Up to 2,000 people without services

Also, to limit the scope of INAPA systems only RWS that had CM organizations that had completed INAPA/AR's decentralization program and achieved status as an ASOCAR where included (See Table 9).

Finally, INAPA or PC systems that were no longer functioning (i.e. permanent system damage or lack of service for more than 1 year) were also eliminated from the pool of potential RWS. It is possible to glean a lot of information from failures related to management and/or technology. However, during the pilot field testing of the surveys after visiting the community of Los Lirios (INAPA system) where service had been discontinued for extensive period of time and it was determined that the difficulty in data collection and the relative quality of the data that could be obtained from sites where the service has been discontinued for extension periods of time, required that such systems be eliminated from the scope. Therefore, a total cohort of 185 RWS (118 PC and 67 INAPA) was used to calculate the sample size used in the surveys. See Appendix A.7-A.10 for a complete listing of the cohorts and samples for INAPA and Peace Corps.

Table 9: Sample Selection Criteria. Three sample selection criteria and a breakdown of the RWS for both INAPA and Peace Corps that meet each criteria: trained community management organization, functioning system, population less than 2,000. The total number of systems that meet all three criteria are listed at the bottom.

#	Sample Selection Criteria	INAPA	Peace Corps	Total
1	Organizations with Community Management Training	81	122	203
2	Functioning systems	75	118	193
3	Populations less than 2000	68	120	188
	Systems that meet all three criteria	67	118	185

The sample size (SS) calculation was conducted using a 95% confidence level. Two different options in calculating the sample size were considered: a) Method A: calculating sample size based on separate PC and INAPA cohorts (118 and 67 respectively) or b) Method B: calculating sample size using total aggregate RWS pool (179) as the cohort. The SS was calculated using Equations 1 and 2 at various confidence intervals (C).

$$SS^{*} = \frac{Z^{2} * (p) * (1-p)}{C^{2}} \qquad \text{Equation 1}$$

$$SS = \frac{SS^{*}}{\left(1 + \frac{SS^{*}-1}{Pop}\right)} \qquad \text{Equation 2}$$

Z = Standardized normal deviation value (1.96 for 95% confidence level)
p = Percentage population picking a choice expressed as a decimal (p=0.5 or worst case scenario)
C = Confidence interval expressed as a decimal (eg-±10 is 0.1)
Pop = Population from which sample will be taken
SS = Sample size to achieve determined confidence level and interval (for finite population)
SS^{*}= Sample size for a very large or unknown population

This method was modified from http://www.surveysystem.com/sscalc.htm (Retrieved on November 11, 2008)

Considering the time and resources available to execute the surveys in addition to the necessary accuracy of the study, it was determined that Method B was preferable with a confidence interval of ±10%. This allowed a sufficient level of investigative quality while maintaining a realistic total sample size of 64 systems.

Early on it was deemed important to focus on the quality or level of detail of the data collection tools and not put undue emphasis on quantity of surveys administered. The results of this analysis are shown in Table 10. The final sample size used for the study was 64 RWS, proportionately represented by INAPA 23 and 41 Peace Corps systems.

Table 10: Summary of the results of the two different options in calculating the sample size. Method A in which sample size is calculated based on separate Peace Corps and INAPA cohorts (118 and 67 respectively). Method B calculated sample size using a cohort equal to the total aggregate RWS pool that met the selection criteria (185 systems).

Method A	**Confidence Interval**		
Cohort	**±5%**	**±10%**	**±15%**
INAPA (67)	58	40	27
Peace Corps (118)	91	54	32
TOTAL	149	94	59

Method B	**Confidence Interval**		
Cohort	**±5%**	**±10%**	**±15%**
Aggregate (185)	126	64	35

6.5.2 . Sample Selection

Various different sample selection methodologies were considered for this investigation: simple random sampling, systematic sampling, stratified random sampling, and cluster sampling. Table 11 provides a short description of each method and the pros and cons associated with each. Due to the actual and perceived differences (socio-economic, climatic, infrastructural, political, and cultural) between geographic regions of the country it was determined that a geographically stratified sample would ensure the most representative results.

Table 11: Evaluation of the Sampling Methods considered for the site selection.

Sampling Method	Description	Pros	Cons
Simple Random	All subsets of the population frame are given an equal probability.	Each element of the frame thus has an equal probability of selection	Possible that the sample will not be completely random. Certain elements might not be represented if their
Systematic	Selecting nth subset on a comprehensive, randomized list of the population frame.	Easy, induced stratification can be efficient	Requires a randomized list. If periodicity/patterns exist in list bias can result
Stratified	Population is divided into strata based on certain characteristics	Ensure particular groups are adequately represented. More control of sample composition.	Variance differences across strata can complicate sample selection (e.g. statistical analysis to determine disproportionate stratification maybe required)
Cluster	First stage: a sample of areas is chosen, second stage: a sample of respondents *within* those areas is selected.	Can reduce travel and other administrative costs.	Generally increases variability of sample estimates above simple random sampling, depending on how clusters differ between themselves, as compared with the intra-cluster variation.

Using the calculated sample sizes the INAPA and PC systems were divided by province. A province is the primary political division in the country (analogous to states in the US). Once the relative number of INAPA or PC systems in the respective provinces was identified, the sample size was calculated in each province. If the number of systems in a given province was above the total mean for all provinces the calculated proportion was rounded down. If the number of systems was below the mean the sample size was rounded up. Tables 12 and 13 show the results. Note that representation by province was proportionate except in cases where provinces had a single RWS in which case that system was included by default. This methodology for calculating the sample size for each province produced a sample size of 42 Peace Corps systems when only 41 are needed for confidence interval selected.

Table 12 (left) and Table 13 (right): The number of RWS by province for INAPA and Peace Corps and the corresponding calculated sample size required from each province to achieve the total calculated sample size. Three were eliminated because the system was not functioning or abandoned (Azua, Bahoruco, and Independencia) and one because logistical difficulties prohibited inclusion of the San Cristobal system selected for the survey. See Appendix A.7-A.10 for a complete list of the communities.

INAPA Systems

Province	# RWS	Calculated Sample Size	Actually Surveyed
Azua	1	1	0
Bahoruco	1	1	0
Barahona	5	1	1
Dajabon	0	0	0
El Seybo	17	5	5
Hato Mayor	9	2	2
Independencia	1	1	1
La Altagracia	1	1	1
La Vega	0	0	0
Monte Plata	7	2	2
Pedernales	1	1	1
Peravia	6	1	1
San Cristobal	9	2	2
San Juan de la Maguana	5	1	1
San Pedro de Macorix	1	1	1
Sanchez Ramirez	1	1	1
Santiago	1	1	1
Santiago Rodriguez	1	1	1
TOTAL	67	23	21

Peace Corps Systems

Province	# RWS	Calculated Sample Size	Actually Surveyed
Azua	9	3	3
Elías Piña	4	2	2
Independencia	2	1	0
La Vega	17	5	5
Monte Plata	4	2	2
Puerto Plata	27	9	9
Salcedo	2	1	1
Samana	1	1	1
San Cristobal	4	2	1
San Jose	9	3	3
San Juan	11	3	3
Sanchez Ramirez	1	1	1
Santiago	27	9	9
TOTAL	118	42	40

The sample selection process used in this research is consistent with field tested research methods. An example, Sara and Katz (1997) recognized the importance of accounting for regional differences and also used similar parameters: communities with 2500 people or less, with more than 15 inhabited households, and whereby possible between 2-5 years old. In order to maintain a geographically representative sample, no system age limits were included. All communities chosen in the study had more than 15 inhabited households with one exception (Los Arroyos, Salcedo) whereby community size has drastically been affected by urbanization and migration out of the community towards the main road and increased services (electricity, higher level water service, and cell phone reception).

6.5.3 Sample Locations

Once the sample number for each province was calculated, the communities were chosen by randomly selecting community names. Appendix A.7 and A.9 provide a list of all Peace Corps and INAPA systems considered, those eliminated (abandoned systems or communities with population greater than the 2,000 person threshold), and finally, those chosen from the random selection process. Figures 10 and 11 show the locations of all the INAPA and Peace Corps cohorts (67 and 118 systems, respectively) and the locations of the sample systems

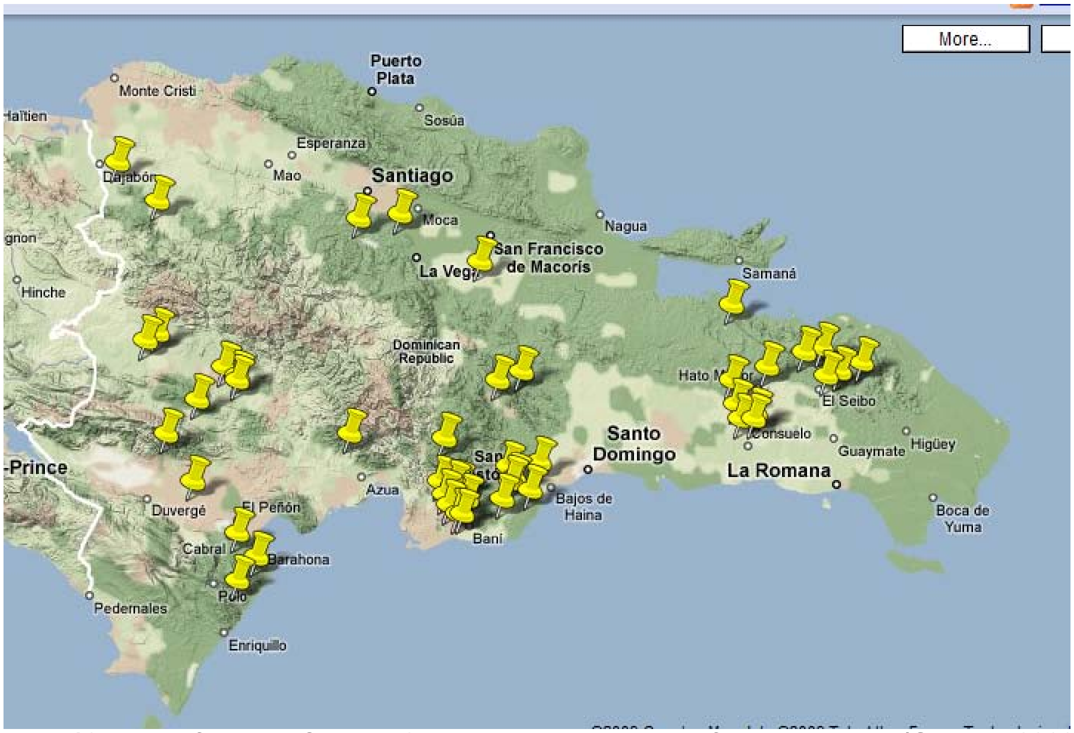

Figure 10: Map of INAPA Cohort, 67 systems, considered for this survey (Google, 2009).

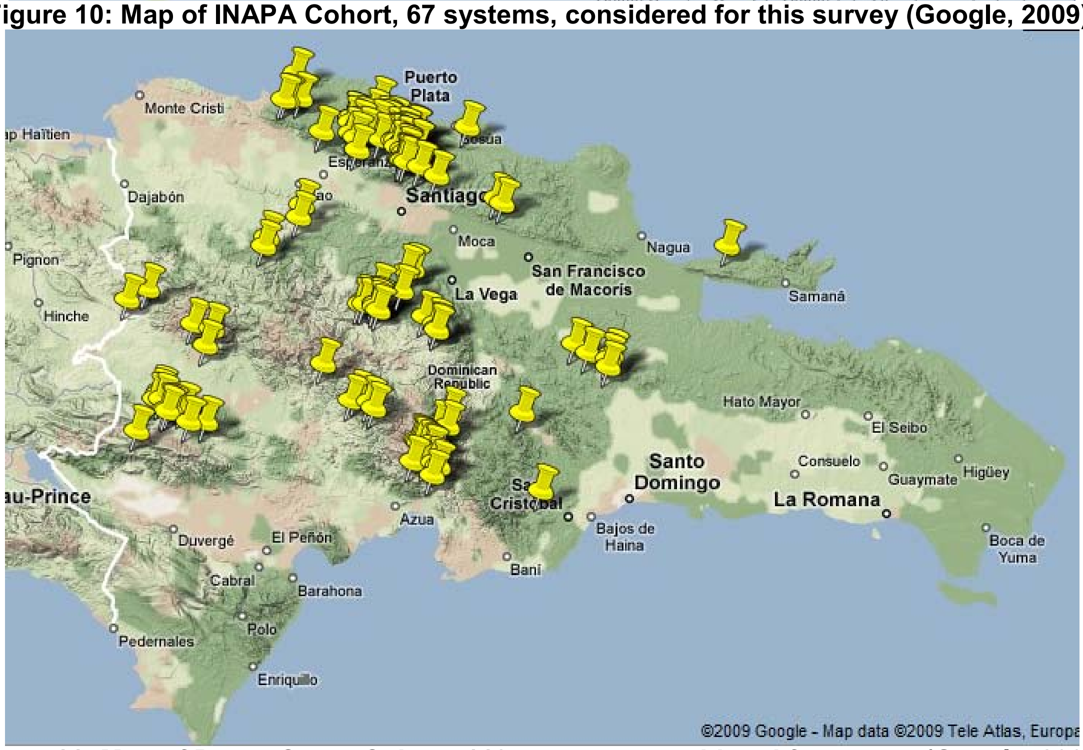

Figure 11: Map of Peace Corps Cohort, 118 systems, considered for survey (Google, 2009).

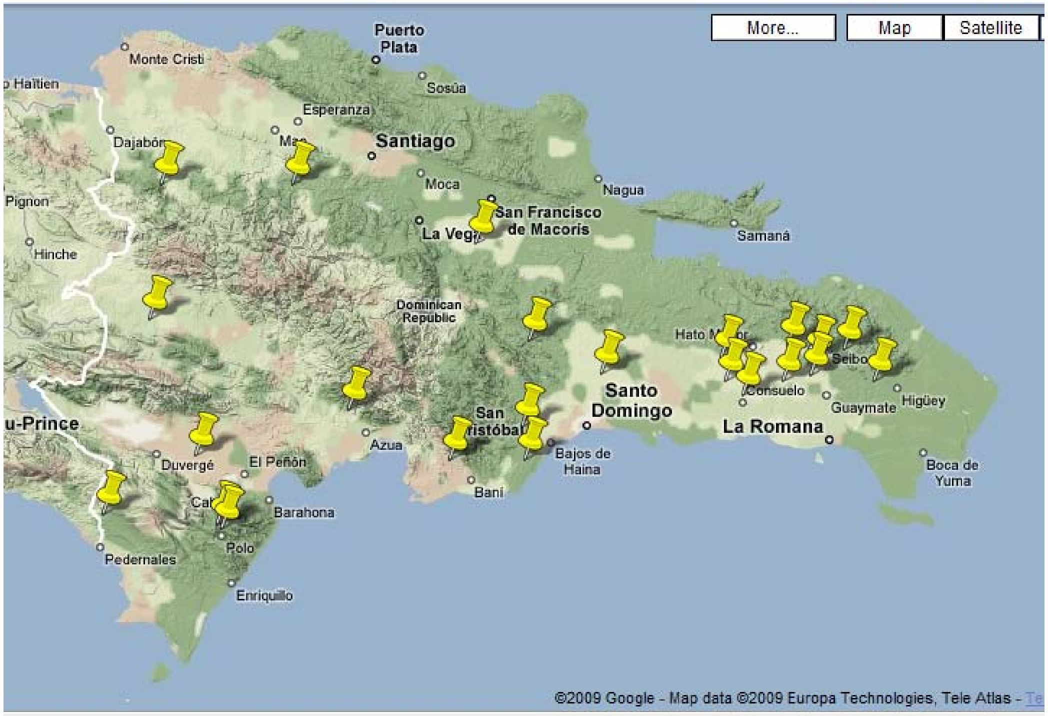

Figure 12: Map of INAPA Sample Locations 23 systems (Google, 2009).

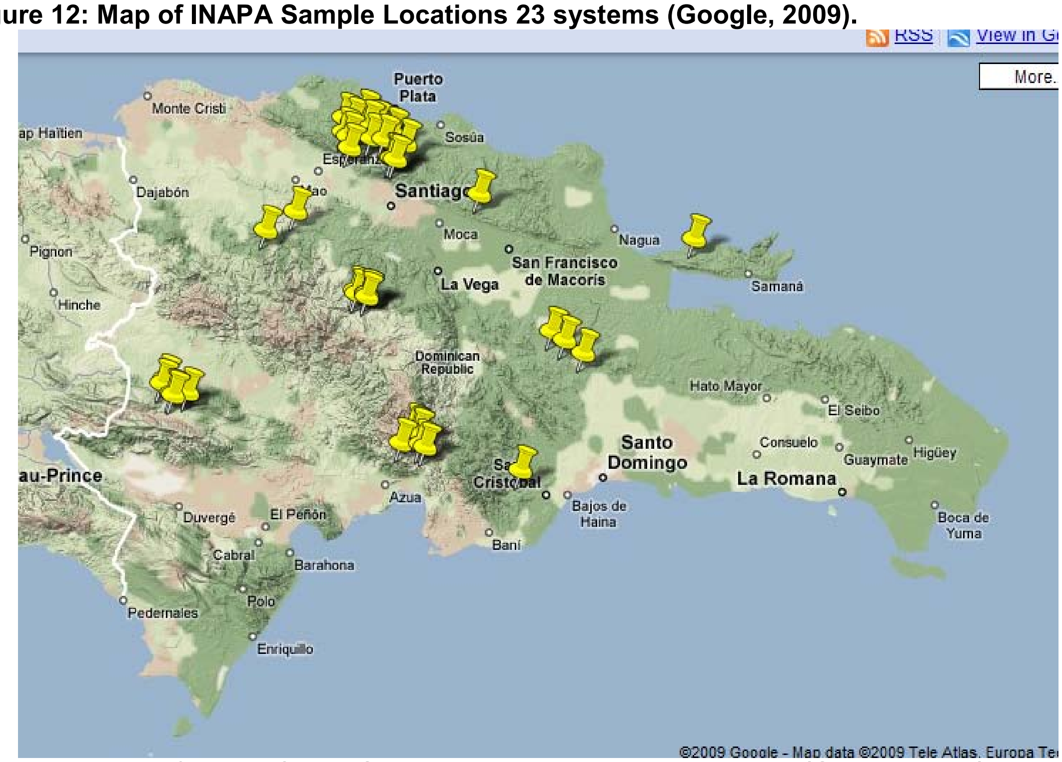

Figure 13: Map of Peace Corps Sample Locations 42 communities (Google, 2009).

Several items can be noted from the maps provided in Figure 10-13. The INAPA systems (Figure 10) are concentrated in two main areas, in the east and also directly to the west of the capital. The density of systems in the area just west of the capital is due to the proximity to the "decentralization" support provide by supervisors that work out of the (central) INAPA-AR office on the west side of Santo Domingo. Supervisors are able to visit these areas with more frequency and hence more systems have established ASOCARs and incorporated.

The second conglomerate, in the eastern provinces of El Seybo and Hato Mayor, (the cluster seen on the right hand side of Figure 10) is a result of the INAPA/USAID decentralization pilot program conducted in these provinces. Also, although INAPA states that gravity fed sources are preferable, they have implemented twice as many pump systems: 62.8% pump, 28.2% gravity, and 9% mixed (Rodriguez, 2008). In the east the flat topography (prohibitive of gravity-fed solutions) and favorable hydrogeology (low depth to ground water) are conductive to interventions using pumps.

It is clear that INAPA systems are more dispersed than the Peace Corps systems, which are grouped in various clusters within the mountainous regions in the western two thirds of the country. Because Peace Corps' primary focus is gravity-fed systems (96% gravity fed, 4% mixed) volunteers are sent to communities in or near the mountains (see Figure 11). Also, due to the volunteer solicitation process (described in Section 5) the systems tend to be concentrated around a single community. When the first community finishes their water system, the surrounding communities investigate to determine how they might get a volunteer, and therefore the only limiting factors are the availability of feasible water sources (springs) and the motivation of the supervisor for the Healthy Environments Program. One factor that greatly affects the decision about where to send volunteers is the potential for funding. Over half of the systems have been built near San Jose de Ocoa, El Cercado, and Altamira. These are three areas where development and religious organizations, as well as politicians, have made significant and repeated contributions to volunteer projects.

7 Data Analysis

Complicated data analysis techniques have been used to describe the interaction between specific variables and indicators of sustainability. Often this type of statistical analysis is utilized for making policy decisions, yet criticism exists that the richness of the collected data is not fully expressed and furthermore such an approach although more complex "inevitably removes the focus of the investigation away from the community, and even out of the country completely" (Lockwood, 2003). Organizations with extensive resources available, such as the World Bank, have tried to develop a statistically intensive evaluation methodology, but success has been limited because it is difficult if not impossible to fit the laundry list of interdependent variables into a "black box" solution (Lockwood, 2008).

It was determined that a less complicated tabular analysis using descriptive and fewer inferential statistics would achieve the objectives set forth and that methodologies emphasizing a more complicated statistical analysis are beyond the scope of this investigation. Such methodologies, like the canonical correlation analysis (Kaliba and Norman, 2009) or the methodology for participatory assessment (WSP/IRC, 2003) have been implemented in other studies and the possibility exists to conduct such studies in the Dominican Republic incorporating data collected during this investigation.

7.1 Precedents for Measuring Sustainability

Three methods to evaluate the sustainability of water projects were evaluated in this study. They are presented in the next three subsections.

7.1.1 The Sustainability Snapshot

A pragmatic yet robust methodology for measuring sustainability was developed previously by the international non-governmental organization WaterAid. The "sustainability snapshot" (summarized in Appendix A.11) uses a participatory process whereby communities are rated (and rate themselves) using three key factors:

- Financial capacity
- Technical skills
- Resources (i.e., equipment and spare parts) available at the community level

The "Sustainability Snapshot" assumes that for these factors to have a positive contribution towards sustainability all other necessary conditions must be sufficient. For example, if the community's technical skills are sufficient (or positively affect the sustainability of the system) and the pumps are working, then the institutional training must have been sufficient to get to that point. Therefore it seeks to measure the three dependent variables only and assumes that this will account for all the preconditions or independent variables. Based upon information and experiences from hand pump projects in Africa, the simple non-prescriptive evaluation procedure implies replicability to other countries and technologies. However, it is unclear how extensively WaterAid has field tested the methodology outside of Africa and what can be inferred about the long term vulnerability of communities. Does it sacrifice rigor for simplicity? Nonetheless, the straightforward evaluation using a three tiered ranking system was incorporated into the sustainability analysis tool of this research.

7.1.2 National Water Supply and Sanitation Company of Nicaragua

The National Water Supply and Sanitation Company of Nicaragua developed an evaluation methodology for use in their regional operations and maintenance support unit (UNOM acronym in Spanish). It is used by technicians to identify which communities will require priority attention. Like the sustainability snapshot, the UNOM method is straightforward and replicable. It is based upon the three "principal aspects" of the water supply project:

- Organization
- Administration
- Technical condition.

Various indicators are measured within each category and an overall ranking of "above average," "acceptable," or "below average" is determined for each community. The sub indicators used to determine the ranking are provided in Appendix A.12**.**

7.1.3 Lockwood: Post-Project Sustainability Report

Lockwood (2003) evaluated literature and project documentation from over 70 different reports and publications (including the WaterAid sustainability snapshot and the database used in Nicaragua) and identified twenty of the most commonly cited factors that influence post construction sustainability of rural water systems. The twenty are divided into five categories with a four-point rating system: 1-highly critical importance, 2-critical importance, 3-less critical importance, 4-limited importance (see Table 14).

Lockwood determined that the two factors most integrally related to post project sustainability (and thus having a rating of highly critical importance) are sufficient financial generation (tariffs, user fees, etc) and external follow up or post-construction support, shown in row 1 of Table 14. The results reflect a composite picture of various studies and are to be used "primarily a tool which serves as the starting point for taking forward the analysis of such factors" (Lockwood, 2003).

Table 14: Twenty most commonly cited factors for post construction sustainability separated by category (technical, financial, community and social, institutional and policy, and environment) and rated from highly critical importance (1) to limited importance (4). The information is taken from Lockwood (2003) and modified from its original format.

Technical	Financial	Community and Social	Institutional and Policy	Environment
	Adequate tariff for recurrent costs		External follow-up support	
Maintenance-preventative Spare parts availability	Adequate tariff for system replacement and expansion	Community management capacity User satisfaction, motivation, willingness to pay	Continued training and support to sanitation/hygiene education	Water Source: production, quality, and conservation
		Involvement of women Social capital or cohesion Continued training and capacity building	Private sector involvement Supportive policy/regulatory environment Legal framework, recognition of water committees and ownership	
Tools/equipment availability Electricity supply/affordability Standardization of components Maintenance-major repairs or replacement			Clarity of roles for operation and maintenance	

Using Lockwood and the UNOM evaluation method as a starting point, literature in the RWS, and the author's thirty-two month field experience in country, the list of factors to evaluate the sustainability of a project was modified. In order to make the Sustainability Analysis Tool more applicable to the Dominican Republic the following four assumptions/changes were made:

1. Consistent with the assumption made by WaterAid that measuring the internal factors inherently accounts for the external factors (see Section 7.7.1), this research focused on factors that are internal to the community. Therefore the following external factors were not included in the Sustainability Analysis Tool: "continued training and capacity building" and all six factors in the institutional and policy category. However, after establishing the sustainability score, the correlation between sustainability and the external factors can be evaluated using linear regression and non-parametric comparisons.
2. In the Dominican Republic the government subsidizes fuel prices and electricity (INAPA pays 100% of all electricity costs in pump systems). Therefore "electricity supply and affordability" was not included in the Sustainability Analysis Tool. Related to this subsidy is the expectation that the government will cover "capital replacement or system expansion costs;" therefore, this factor was also excluded. The importance of cost recovery in system sustainability however has bee recognized (UNICEF, 1993).
3. Transportation in the DR is extensive and relatively inexpensive; therefore "spare parts availability" is in reality of limited importance and was not included in the Sustainability Analysis Tool.
4. Compared to Africa the level of coverage in water and supply is much higher. Although the design and construction techniques are not standardized per se, there is a harmonization whereby suppliers carry only a limited range of components and equipment. In addition, no hand pumps were included in this study as they are gradually becoming an unacceptable option in RWS. Consequently, "standardization

of components" and "tools equipment availability," which are really more pertinent for hand pump systems, were excluded.

The remaining eight factors together create a streamlined Sustainability Analysis Tool. Like the WaterAid and UNOM models, this tool functions as a community diagnostic tool, focusing on the capacity of the community and assuming that the external factors are indirectly accounted for. Although many factors were not included, it is important to note that these factors can have a significant effect on sustainability. In order to gauge if some of these factors are important, this research compares eight individual indicators with the final sustainability ranking through descriptive and inferential statistical comparisons.

7.2 Sustainability Analysis Tool

The Sustainability Analysis Tool used in the study is a synthesis of the evaluation procedure of: 1) the Sustainability Snapshot, 2) the organizational structure, indicators, and some of the thresholds of the UNOM method, and 3) the hierarchy of Lockwood's critical factors affecting RWS adapted to the realities of the Dominican Republic. Each community was evaluated using eight indicators that are grouped into three general areas: organization/management, financial administration and technical/service. Two critical thresholds were established for each of the eight indicators. Table 15 shows the list of indicators developed for this study and their corresponding thresholds. These critical thresholds separated the communities into three groups (similar to WaterAid and UNOM):

1) sustainability likely (SL)
2) sustainability possible (SP), and,
3) sustainability unlikely (SU). (See Section 7.2.2 for definitions)

The rationale for specific thresholds applied to the 8 indicators is presented in Table 17. The rationale for each specific threshold was developed from the author's 32-month in-country experience, Peace Corps and INAPA documentation and training materials, and/or relevant values from literature in the RWS field.

	Indicator	Sub-Indicator (Variable)	Type	Sustainability Unlikely (SU)	Sustainability Possible (SP)	Sustainability Likely (SL)	Survey Ref #
Organization/Management	Activity Level	# Water committee active	Quasi-Numeric	1 person or less	2 people	3 people or more	1.3
	Participation	Average percent attendance at community meetings	Numeric	X < 50%	50% ≤ X < 66.6%	X ≥ 66.6%	1.7
	Governance	Decision making process*	Qualt.	Individual or small group decision, no apparent process, arbitrary	Water committee decides by majority rule, transparent decision making steps	Open discussion, democratic, community involved, water com facilitator role, systematic	1.9 1.10
Financial Administration	Willingness to pay	% Delinquent in payment of tariff	Numeric	X > 80%	80 ≥ X >10%	X ≤ 10%	1.22
	Accounting records and transparency	Accounting Ledger and Frequency of Reports	Binary	No ledger AND no reports /reports less frequent than 1X a year	Use ledger OR Report at least once a year	Use ledger AND Report at least once a year	1.22b 1.30
	Financial durability	Wages, costs, tariff, % debtors, # CXNs	Numeric	Income ≤ O&M AND Less than "significant savings"	Income > O&M OR "significant savings"	Income >O&M AND "significant savings"	1.2 1.4, 1.17 1.21 1.22 1.37 1.38 3.4 3.12
Technical/Service	Repair service	Days w/out service in last month	Numeric	More than 5 days	1 to 5 days	Less than 1 day	1.35
	System Function	Hours/Day (averaged over week)	Numeric	**Both** x < 8	**Pump** 8 ≤ x<12 **Gravity** 8 ≤ x<16	**Pump** X ≥ 12 **Gravity** X ≥ 16	1.38a 1.38b

Table 15: Sustainability Analysis Tool developed for this research is based upon WaterAid and National Water Supply and Sanitation Company of Nicaragua UNOM evaluation methods. Survey reference numbers are associated with the Water Committee Focus Group Survey (Appendix A.2)

7.2.1 Response Scoring

In order to simplify data analysis, whenever possible, responses were represented numerically. For those indicators that did not depend on a numeric response (only 2 of 8), data were assigned a score based upon the principle that 1 represents a positive contribution towards an indicator and 0 represents no contribution. A similar methodology has been used in previous sustainability assessments applied to community water utility projects in Central Tanzania (Kaliba and Norman, 2009). Table 16 shows the four data types and scoring system used for each, as well as an example question from the Water Committee Interview Form (Appendix A.2). Ordinal data was collected, but it is the only data type not included in the Sustainability Analysis Tool.

Table 16: Four data types collected during research, an example question from the survey forms used, and the response score for each. Ordinal data was not included in the Sustainability Analysis Tool. The ranking methodology has been used in other sustainability assessments such as Kaliba and Norman (2009).

Data type	Example Question from the Water Committee Interview Form	Score
Binary	Does the community have by-laws? (applicable indicator: accounting records and transparency)	Yes=+1 No=0
Ordinal	How is the water system functioning? (not applicable to specific indicator)	Very Well=+1 Well=+0.75 Regularly=+0.5 Poorly=+0.25 Horribly=0
Numeric/ Continuous	What is the bank account balance? (applicable indicator: financial durability)	Numeric value used (no score)
Qualitative Analysis	What decision making process does the community use? (applicable indicator: governance)	Range of responses established and divided into appropriate subdivisions.

The indicator of "Activity Level" (Organization/Management area) is a special case as it involves qualitative, binary, and numeric variables and hence called quasi-numeric. Each water committee member was assigned an individual activity level score (binary) based upon information from the focus group and key informant interviews. To be considered "active" a person had to be identified as active by both the water committee and at least one key informant (INAPA supervisor, PCV/PC database, or plumber/operator).

The information provided by these sources was easily triangulated by observation. It was nearly universal that the meetings took place in the home of an "active" person (if not, then it was a public place). It was also common for the active members to be in charge of materials or supplies even if it was not necessarily associated with their general job description on the committee (e.g. a treasurer that stores maintenance tools or a president that keeps the accounting books and money). It is worthwhile to note that in no case was anyone ever mentioned as active and not on the water committee.

7.2.2 Indicators and Thresholds

Definitions were developed to establish divisions between the three categories of performance used in this study: 1) "sustainability likely", 2) "sustainability possible", and 3) "unlikely sustainable" (referred to SL, SP, and SU, respectively, from here on). The following definitions were obtained by modifying the WaterAid Sustainability Snapshot and the Unit of Operation and Maintenance (UNOM) evaluation table created by the National Water Supply and Sanitation Company of Nicaragua. (see Appendix A.11 and A.12).

Sustainability Likely (SL) - Organizational, administrative, and technical capacities are significant. Resources (financial and material) are available and sufficient for the most expensive maintenance process. Service levels and participation are reflective of a well functioning system.

Sustainability Possible (SP) - Organizational, administrative, and technical capacities are acceptable. Resources (financial and material) are available but not sufficient for the most expensive maintenance process. Technical skills are acceptable for routine corrective maintenance.

Sustainability Unlikely (SU) - Organizational, administrative, and technical capacities are unacceptable. Resources (financial and material) are not available when needed or insufficient. Technical skills are unacceptable for maintenance demand.

Following these definitions it is necessary to explicitly identify the thresholds (quantitative and/or qualitative) between SL, SP, and SU. For a list of the thresholds see Table 15. Thresholds were based on previously established benchmarks used in the Dominican Republic by INAPA or Peace Corps, applicable values used in RWS studies and literature developed from around the world (particularly the UNOM model), and/or the author's 32 months of field experience. A summary of the sources used to establish the thresholds for each of the eight indicators is shown in Table 17, and the following section discusses in detail how each threshold was determined.

Table 17- Sources of the benchmarks and empirical values justifying the critical thresholds, upper and lower (two per indicator), used to evaluate each community in the Sustainability Analysis Tool.

Indicator	Threshold justification and/or Source
Activity Level	UNOM, Relative Frequency histogram, and author's in-country experience.
Participation	INAPA guidelines, Narayan (1997) and author's experience
Governance	INAPA and Peace Corps training materials and author's experience.
Willingness to pay	UNOM, Relative Frequency histogram, Non parametric statistical comparison, and the author's in-country experience.
Accounting and transparency	INAPA Standard and Norms, UNOM, and author's experience
Financial durability	INAPA and Peace Corps guidelines, UNOM, and author's experience

Indicator	Threshold justification and/or Source
Repair service	INAPA definitions of plumber/operator workload. Lockwood (2004), Sara and Katz (1997), UNOM, and author's experience
System Function	UNOM minimum service level (hours/week with water) and Peace Corps and INAPA design criteria. Non parametric statistical comparison

7.2.2.1 Benchmark Thresholds

7.2.2.1.1 Participation

There are strong statistical findings that show that increasing participation of beneficiaries directly causes better RWS project outcomes (Isham et al, 1995 and Narayan, 1995). In the DR there are two established benchmarks: INAPA's "Reference Articles for ASOCARs" by-laws document outlines conditions for the proper functioning of ASOCAR and RWS. Chapter 10 Article 73 states that two-thirds (66.6%) majority of beneficiaries should be required to dissolve or liquidate the ASOCAR or change by-laws. By definition this establishes a critical participation threshold for effective and successful governing the system. Therefore, by the relationships established by Isham et al. (1995), this participation level suggests a likelihood of sustained project benefits (i.e. SL). Also mentioned in Chapter 2, Article 14, is the minimum attendance to establish quorum (50% plus one) and proceed with meetings. Although this threshold is not as explicitly related to sustainability, in the author's experience average percent attendance at community meetings below 50% is an indicator of problems (social cohesion, satisfaction, etc). Therefore, although it is possible that a system could function perfectly and have low participation, it is considered undesirable and a risk to the sustainability of the system.

7.2.2.1.2 Governance

The only strictly qualitative metric (sub-indicator) used in the sustainability tool is the "Decision Making Process" of the Governance indicator. To stratify communities a comprehensive list of responses to Questions 1.10 and 1.11 of the

"Water Committee Form" (see Appendix A.2) was made. The list was then divided into three categories based upon the keywords shown in Table 15, with the justification that in the absence of transparent and inclusive governance there is a diminished conflict resolution capacity.

Communities that used a systematic and democratic decision making process (Q#1.10) involving the water committee and the community at large received an SL rank and if decisions were made, democratically, but if by the water committee alone, an SP. Sustainability is unlikely if decisions are made by an individual or small minority within the committee. Under such a situation a misguided or malevolent individual/group can mismanage the system. In addition, an efficient and effective "sole proprietor" can pass away or move out of the community leaving the community without the experience or capacity to run the system.

Therefore the sustainability of the system is dependent on participatory processes involving a significant amount (at least simple majority) of the community, and under the ideal situation the water committee plays an active and facilitative role making recommendations to the community for major decisions and taking the initiative on smaller issues. In the author's experience water committees with a high level of participation and organization attract more projects and leverage outside investment. This assumption is consistent with and reflects the emphasis of participatory processes in the RWS sector (Narayan, 1995; Sara and Katz, 1997).

7.2.2.1.3 Accounting Records and Transparency

INAPA standards and norms documents define the required frequency of financial reporting by the number of household connections within the system. Annual reports are the minimum required for all communities and for larger communities reports are more often: biannual (101-150), quarterly (151-300), and monthly (500+). The average number of connections is 60 for PC projects and 110 for INAPA projects, and therefore annual reports are the minimum required. In addition, the minimum level

of accounting organization necessary is a ledger notebook (as seen in Figure 14). In all case where a ledger or some type of similar accounting record was not used, the community was not collecting any money, and therefore the sustainability is in question. USAID (2006) also made the connection between administrative tools (minutes, income/expenditures books, or registries) and the proper functioning of the system.

Figure 14: Example of an Accounting Ledger (Photograph taken by author)

7.2.2.1.4 Economic Durability

Based upon the agreements established by both INAPA and Peace Corps with the community, it is the communities' responsibility to cover the operation and maintenance costs (except for electricity on INAPA pumps systems). Therefore in order to be sustainable the community must have sufficient income to cover operation and maintenance costs and in addition have "significant savings" for eventual crisis maintenance activities, as defined by Lockwood (2004). The most common and expensive repairs for systems are: pump motors (for pump systems) and reconstruction/repair of river crossings or spring boxes after a catastrophic weather event (for gravity systems). Based upon the author's estimate 25,000 RD and 10,000RD is significant savings to cover costs for the repairs to pump and gravity systems respectively. Systems will likely be sustainable (SL) if both conditions are met, and possibly sustainable (SP) if either condition is met. With limited economic capacities and very little assets, in the absence of sufficient tariff generation and with insignificant savings, the sustainability of a system would be severely jeopardized by extreme weather events, which are common in the DR.

7.2.2.1.5 Repair Service

One way to indirectly gauge the functioning of the system is the efficiency of repair. This is measured by the number of days required for repairs, or more specifically, days without service due to repairs. INAPA guidelines state that the average weekly work requirements (including maintenance repairs and operation duties) should be about 6 hrs/wk (less than 51 connections), 12 hrs/wk (51-150 connections), and 24hrs/wk (151-300 connections). Assuming these baseline measurements represent preventative and corrective maintenance then it is reasonable to assume that interruptions in service for more than a day would have to be considered crisis maintenance situations following Lockwood (2004) or reflect technical or administrative deficiencies in the repair service. No "crisis" situations were reported during the surveys and therefore SL is less than one day without service. In order to account for extenuating circumstances, the SP-SU threshold was set at more than 5 days without service. This is consistent with the author's experience and the thresholds used by Sara and Katz (1997).

7.2.2.2 Logical Thresholds

For the remaining three indicators (Activity Level, Willingness-to-Pay, and System Function) no benchmark existed or it was necessary to modify one threshold of the benchmark for the logical conditions in the field. Therefore grouped relative frequency histogram plots were used to establish logical thresholds that were later validated using nonparametric correlation techniques.

By plotting data as a frequency histogram it is possible to identify clusters or patterns and derive logical thresholds. Class intervals are selected in order to present the data in the most meaningful way and accepted rules of thumb that exist were followed; 10 intervals for data expressed as a percentage and in all cases a 6-interval minimum (Blair and Taylor, 2008). It was also assumed, based upon the data selection methodologies (see Data Selection Section), that the sample was statistically representative of the total population cohort.

7.2.2.2.1 Activity Level

Figure 15 shows the relative frequency of the total number of active water committee members for each of the 61 communities (grouped into six intervals). The results show that the data could be approximated by a normal distribution around the average 2.5. Field observations were used to establish the thresholds for this indicator (see Table 15 for thresholds).

Twenty percent (8 communities) mentioned some crucial moment during the community management of the system when a vital committee member moved out of the community, passed away, or was not able to continue in their role, which had significant negative consequences. Appendix A.13 provides a list of field observations supporting what is termed the "charismatic individual effect". This "Charismatic Individual Effect" can influence, positively or negatively, the sustainability of the water system. Although it may be difficult to measure charisma, it is possible to measure how susceptible a community might be to the absence of any potential "charismatic individuals." This evaluation assumes that such persons are inherently included in the active group.

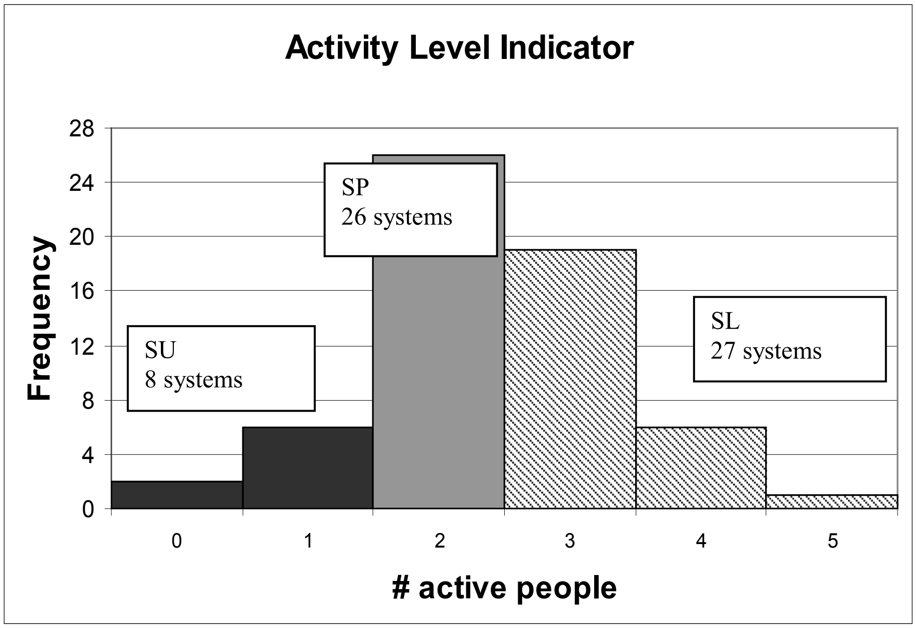

Figure 15: Activity Level Indicator Frequency Histogram. Using the total number of active water committee members the threshold values for sustainability unlikely (SU), sustainability possible (SP), and sustainability likely (SL) are shown. "Activity" was based upon information from the water committee/key informant interviews, secondary sources, and observation.

Using a definition where "active" is positively correlated to "responsibility" (i.e. more active equals more responsibilities or tasks), having more people that are active should mean a community would be more elastic and thus less susceptible to the negative effects associated with the absence of a charismatic person. Accordingly, a rating of sustainability unlikely (SU) was assigned if it was determined there was 0 or 1 active members on water committee. Although, having more than 2 active members does not guarantee sustainability, having 3 or more reduces the probability of deadlock among active members. In other words, the probability of equal people voting opposite ways (i.e. "deadlock") on a binary decision (Yes/No) for two people is 50%, 4 is 38% and 6 is 28% (for 3, 5, 7, etc it is 0%). Therefore, sustainability possible (SP) was assigned if there were 2 active members and sustainability likely (SL) if it was identified that there were 3 or more active members.

7.2.2.2.2 Willingness-to-Pay

The variable measured for the willingness to pay indicator is the percent of households reported to be delinquent in payment of the monthly tariff, defined by Peace Corps and INAPA as owing three months or more. The assumption has been made that this metric reflects the willingness to pay and not the ability to pay because tariff levels in the DR are well below international standards and within the ability to pay of nearly all individuals.

The World Health Organization (WHO) states that households should not be asked to surrender more than 3.5% of their monthly income to pay for basic water supply. Under PLANAR, INAPA based tariffs upon 5% of the minimum monthly earnings in the community. Although minimum monthly earning data was not collected in the surveys, using the provincial average of monthly income shows that in no community does the tariff constitute more than 1.6% of the average monthly income for that province. A more rigorous comparison using primary data from the household surveys shows that in no community did the monthly tariff represent more than one average day wage for six hours of non-skilled labor. In fact, the maximum monthly tariff (100 RD) is less than the minimum average daily wage (106 RD). Therefore, although literature exists challenging the use of average income as an acceptable measure of ability to pay (Orr, 2009) the actual deviation between minimum and average income does not make such nominal tariffs prohibitive.

Table 18: Monthly Tariff, Average Monthly Income, and Average Daily Wages for Surveyed Communities

	Monthly Tariff	Average Monthly Income		Average Daily Wage	
	(RD/month)	Provincial Average	(%)	H.H surveys	(%)
Gravity	19	4088	0.5%	252	8%
Pump	56	4211	1.3%	295	19%
Solar	54	3709	1.5%	242	22%
All	29	4073	0.7%	259	11%

Furthermore, evidence suggests that on the community level the tariffs are established according to ability to pay, as wages increase (e.g. the ability to pay) so does the tariff (see Figure 16). The exceptions to this (shown as outliers indicated in Figure 16) represent solar pump systems that usually are associated with higher tariffs for maintenance and additional costs (e.g. payments to night watchmen to guard the solar panels).

In addition, when asked how the tariff was established 89% of water committees cited that the community had the final decision. The remaining 11% did not remember how the tariff was established or did not respond to the question. In one community the tariff was set at 5 pesos (0.15 USD) a month, an amount that the respondent admitted "everyone here can pay." It was raised to 10 and finally 30 pesos, yet the level of delinquency did not change, because the people simply did not want to pay. Adjustments are often made for the poorest households to facilitate payment (in kind contributions, paying after harvest, etc). Finally, it was very common for widows and elderly to be exempted from collection lists and hence discounted in the delinquency payments. Therefore, the level of delinquency or non-payment of tariffs is assumed to represent willingness to pay.

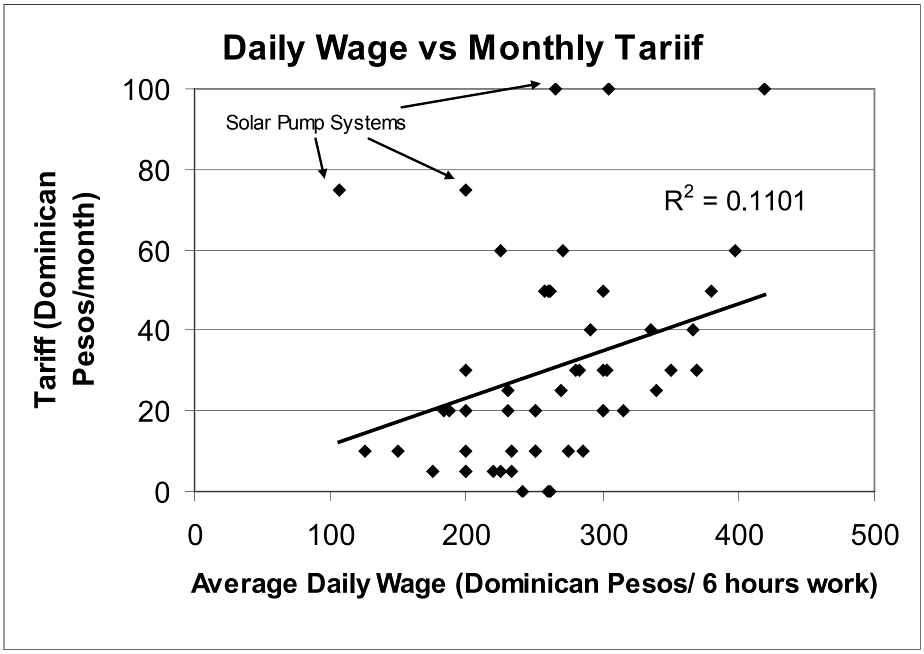

Figure 16: Average Daily Wage versus Monthly Tariff. This shows that as wages increase so do tariff levels suggesting that the level of payment can be a proxy for Willingness to Pay.

Observing the histogram of the percent delinquent shown in Figure 17 reveals a dichotomous pattern. A large amount of systems are grouped around the ends; high delinquency at the right and low delinquency (compliance with financial obligations) at the left. From Figure 17 it was determined that reasonable thresholds of greater than 80% delinquent resulted in sustainability unlikely (SU) and less than or equal to 10% delinquent resulted in sustainability likely (SL). This particular sustainability likely (SL) threshold is consistent with and slightly more liberal than that used in the UNOM method: “at least 90% of households contributing financially” (Lockwood, 2001).

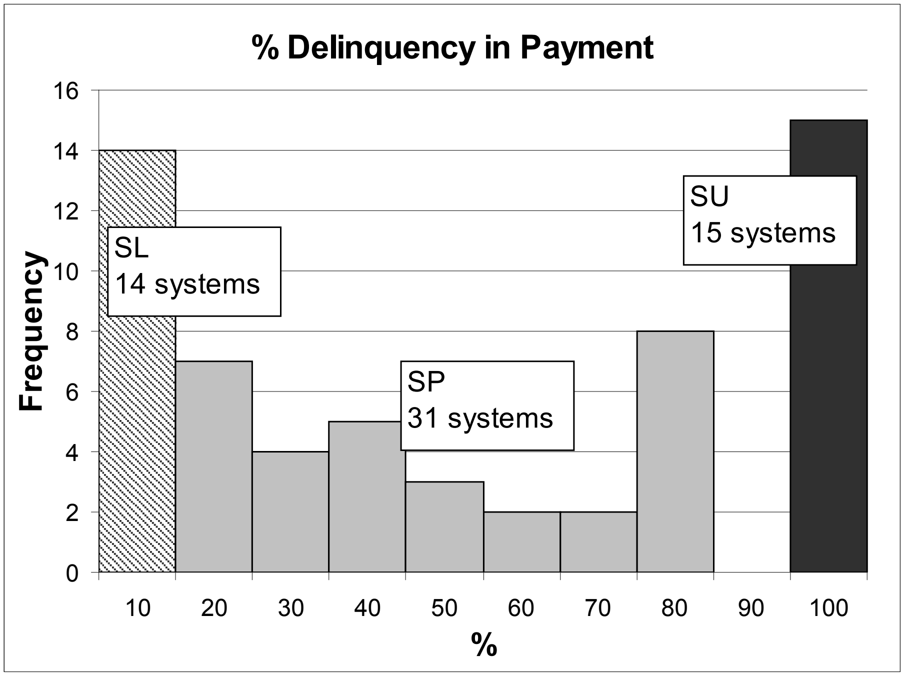

Figure 17:Willingness to Pay Indicator Frequency Histogram. The variable measured for this indicator is the percent of the community that owes three months of tariff or more.

Although high levels of payment might indicate systems that are financially unsustainable, there are cultural factors that affect exactly how this indicator is divided between the three categories of performance; SU, SP, and SL. One important aspect to consider is the cyclical nature of household incomes in an agriculturally based economy. Only 57% of communities said they sanction people who do not pay and 51% reported that at some time they have suspended service for delinquency in payment. This is due to the common belief that "it is a crime to deny somebody water" and it is "necessary to talk to them [the debtors] and give them a chance to pay." A cultural reality in the Dominican Republic is that sharing is expected and that deadlines, especially payment deadlines, are flexible. It is common to give people a chance, often months, until the next harvest, when more capital was available. In this study, 95% of the communities cited agriculture as the main source of income.

A case study of 9 systems in the province of Hato Mayor in the east showed similar levels of delinquency (20-50%) to those in this research (52% average) (USAID, 2006). One potential source of bias in the research data is that the majority of surveys took place during the dry season when people are often strapped for cash. Accordingly, the results may be biased to rating some communities less sustainable over the long term in regards to this indicator.

In addition to the income patterns of the agricultural communities, there is also a tendency for individuals to have a short term reactionary outlook. Therefore many communities rely not on individual monthly payments, but on a system of *recoletas* (collections), only collecting money for major repairs. Unfortunately this approach may have a negative impact on the long term sustainability of a system because it is well documented that preventative maintenance can reduce costs over the long term. The nonpayment culture ties directly into the lack of awareness and preparation that limits the useful life of the systems in the medium and long terms (USAID, 2007).

Embedded in the willingness to pay is the pricing of water services (as low as 15 cents a month in some communities). Studies have shown that underpriced services lead to: under-investment, poor maintenance, poor technical performance, slow progress in extending coverage, and wastage of water (Parry-Jones, 1999).

7.2.2.2.3 System Function

The variable used to measure the system function is the number of hours per week that there is water in the system, converted to a percent for ease of analysis. This dependent variable reflects the actual functioning of the system and depends on water use/misuse, specific system design factors, and source production. In order to maintain simplicity of the analysis tool it was determined to exclude these independent variables.

Figure 18 shows the histogram resulting from the "System Function" indicator and examination reveals three general clusters in the data. In order to isolate for technological complexities, the data in were also broken down into total systems, gravity flow, and pump systems. Figure 18 shows that the majority of gravity systems (25 out of 44) operate more than 90% of the time, while only a small percentage of pump systems do (3 of 17). Given the simplicity of gravity fed water system design and the prevalence of electricity blackouts, this difference was expected and does not necessarily represent a disability in community management.

All RWS included in the study incorporated a water storage system to meet flow during peak demand periods: average of 40 gallons per person for gravity systems and 28 gallons per person for pump systems. Properly designed pump systems, even with limited electricity, can provide water on a continuous basis. However, if electrical services drop below the critical levels used in design, the water service will be affected. Therefore, in order to establish the proper thresholds for this indicator it was deemed necessary to disaggregate and analyze the data for gravity flow and pump systems separately.

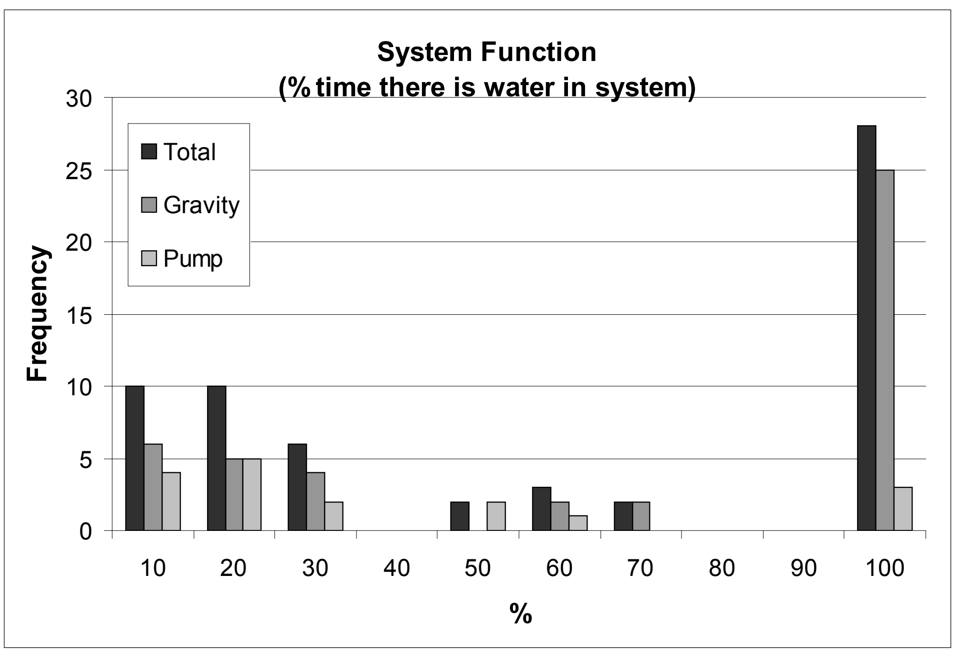

Figure 18: System Function Indicator Frequency Histogram for all, pump, and gravity flow systems. System Function measures the percent of time, averaged over a week, that there is water in the system. The data is obtained from the water committee interview and plumber/operator interviews.

Springs produce water continually. Therefore, if the distribution system is functioning properly, this would result in water arriving at the storage tank continually. However, some communities shut the valve exiting the storage tank at night to control prohibited nighttime irrigation activities. Accounting for 8 hours of suspended service at night, properly functioning systems should still operate over 66% of the time (i.e., 16 of 24 total hours). Using the clusters, a value of less than 33% of the time (8 hours/day) was used for the SU threshold as it suggests that water is either being grossly misused, improperly partitioned, or the supply is inappropriate to meet the demand (or any combination of these).

Assuming that pumps provide a lower level of service because of electricity constraints, it is necessary to separate what these *apagones* (blackouts) effects from other issues (water quantity, water use, administration). The *apagon* effect is isolated by breaking the pump systems down into solar and grid connected pumps. In order to make a fair comparison of solar pump systems to grid powered systems it is necessary to account for differences in design and operation. In general, due to the high initial capital costs of solar panel systems and operational factors the designed level of service (e.g. volume of water or time of service) for solar pump systems is lower (Karp and Daane, 1999).

Figure 19 shows a breakdown of pumping system function by the source of energy: solar and electrical grid. The similar distribution between solar and grid systems shown in Figure 19 suggests that electricity source does not affect the system function to a great degree. In fact the difference in the data is not statistically significant using the Pearson's Product-Moment Correlation Coefficient (see Section 7.2.3). This could mean that electricity is not as important as the functional difference between gravity fed and pumping systems. Nevertheless the difference between gravity fed and pump systems is significant. Therefore it was determined that a lower threshold (SP-SL) would be used for pump systems to represent this difference.

Reflecting this difference a value of 12 hours/day (67% of the time) was used as the threshold for pump systems (SP-SL).

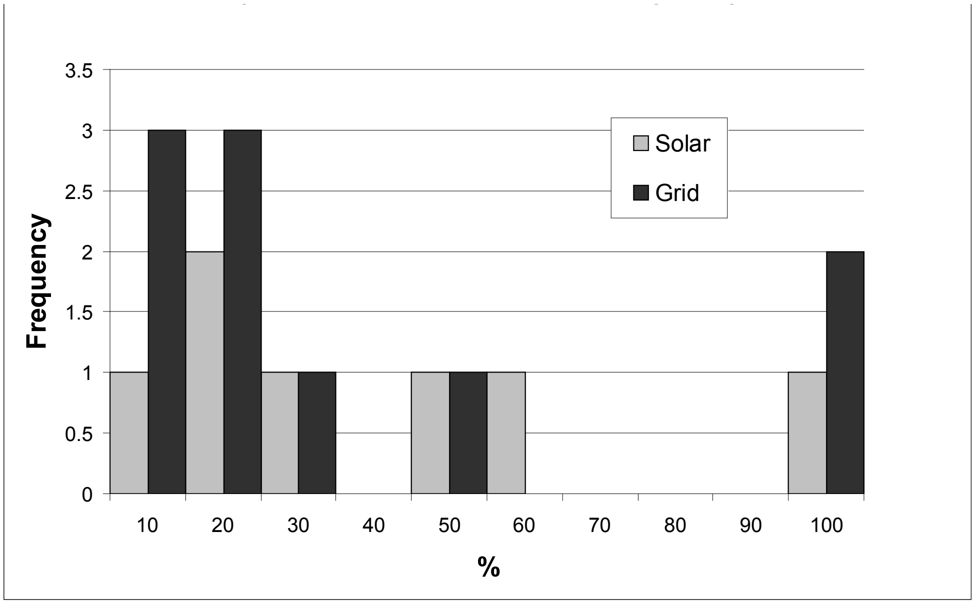

Figure 19: System Function Indicator Frequency Histogram for Solar and Grid-Connected Pump Systems.

A commonly accepted minimum system function threshold, 8 hours/day of water service (SU< 33%), is used by ENACAL and also used by Peace Corps and INAPA in their water storage design calculation as it reflects the hours of peak demand. Therefore, the same minimum system function threshold 8 hours/day was used for both gravity and pump systems.

7.2.3 Verifying the Thresholds

A simple non-parametric comparison was used in order to verify the thresholds used to established SU, SP, and SL for each of the eight indicators in the analysis tool. Nonparametric correlation techniques are designed to estimate the correlation or association between variables measured on nominal and/or ordinal scales, or metric variables that have been reduced to nominal and/or ordinal scales. Such techniques are used to assess how well an arbitrary monotonic function can describe the relationship between two variables, without making any other assumptions about the particular nature of the relationship between the variables. The goal of this comparison is to see if the calculated indicator scores (established based upon the benchmark and logical thresholds) are correlated to an objective measure of system sustainability. If the indicator scores do come from the same distribution then the established thresholds are verified.

The indicator scores (0, 0.5, and 1) were compared to the responses of question #2.8: "How have they responded to the challenges during their administration/stewardship of the system" (See Survey Appendix A.3 and the data/responses in Appendix A.14). Responses to question #2.8 were an ordinal range (0, 0.25, 0.5, 0.75, and 1). This is seen as an independent objective measure of the functioning of the water committee and the water system in general, derived from INAPA supervisors and Peace Corps Volunteers with extensive experience in these communities.

The statistic used to evaluate the correlation between these two data sets was a special case of the Pearson's Product-Moment Correlation Coefficient, called Spearman's Rho, (see Equation 3). The null hypothesis of the test is that there is no correlation between the data sets (indicator scores and Q#2.7) or that Rho is 0. At a probability of less than 5% we can reject the null hypothesis and accept that the data sets are correlated. The test results shown (see Appendix A.15) show that the data sets are correlated for all the eight indicators, verifying the thresholds previously established. It is also important to note the positive rho values, which signify that as the indicator scores increased (i.e.-systems are more sustainable) the communities were identified as being more proactive and capable by the expert. The correlation shown by the Pearson's test does not imply causation.

$$\rho = \frac{n(\sum x_i y_i) - (\sum x_i)(\sum y_i)}{\sqrt{n(\sum x_i^2) - (\sum x_i)^2}\ \sqrt{n(\sum y_i^2) - (\sum y_i)^2}}. \qquad \text{Equation 3}$$

In order to further validate the thresholds determined logically, the indicator scores were compared to the responses to question #2.7: "What have/has been the greatest difficulties that the Water Committee have/has encountered in the O & M of the system" (refer to Appendix for data). The data set from this question are the cumulative score (0-6) of the binary (yes=1/no=0) to the present of difficulties in different areas. For example, a score of 6 represents a community that had difficulties in all areas, and a score of 0, in no areas. The Pearson Correlation shows that the data set is correlated for activity level and willingness to pay, but the null hypothesis can not be rejected (Can say that the data sets are not correlated) for system function. Despite this the established system function thresholds were used.

7.2.4 Weighting the Indicators

Based upon the thresholds (Table 15) established in section 7.2.1, each community was given a designation of SU, SP, of SL for each of the eight indicators. Using numerical scoring as described in section 7.2.1, these designations were quantified (SU=0, SP=0.5, or SL=1). Finally, in order to establish an overall sustainability score for each community it was necessary to identify the relative weights of each indicator. Since the literature suggests that each indicator is not of equal importance (e.g., refer back to Table 14), a weighting system was used where each of the 8 indicators were provided a numerical weight adopted from Lockwood (2003).

$$\text{Overall Sustainability Score} = \text{Indicator Score } (0, 0.5, \text{ or } 1) \times \text{Weighting Factor}$$

The rating assigned by Lockwood was used as a weighting factor for each of the 8 indicators. Lockwood's indicators for post-construction sustainability were separated by category (technical, financial, community and social, institutional and policy, and environment) and rated as: 1) highly critical importance; 2) critical importance; 3) less critical importance and 4) limited importance (4). Table 19 provides the corresponding numerical weighting factor used in this study that corresponds to a particular numerical rating identified by Lockwood.

Table 19: Weighting Factors used in this study that corresponds to a particular numerical rating identified by Lockwood (2003). For a complete list of the indicators and associated rating factors see Table 14.

	Lockwood Rating Score	Weighting Factor Used in This Tool
Highly critical importance	1	4
Critical importance	2	3
Less critical importance	3	2
Limited importance	4	1

7.3 Limitations of Methodology

A potential weakness of the approach used in this sustainability analysis tool is that information was collected only at a single point in time (about 5-6 years after construction) for systems with a design life of fifteen to twenty years. The indicators must, therefore, be taken at face value as indicators, or predictions of sustainability, not as observable measures of long-term sustainability.

In addition, although gender specific water committee and key informant data was collected, a sufficient analysis of this data was determined to be beyond the scope of this thesis. The scarcity of gender disaggregated data in the RWS in the DR is recognized and there is a great need for determining the critical factors that affect the participation of women in water committees. Although both Peace Corps and INAPA have specific gender based participation goals, evidence shows that these objectives are very rarely met. Further research into the cause and effects of these factors is needed.

8 Results and Discussion

8.1 General System Profile

As previously discussed, INAPA and Peace Corps systems were selected because they represent different: 1) organizational structures, 2) operating conditions and procedures, and 3) financial means. However, the goal of each organization is the same. Table 20 provides a summary of the profile of the 61 communities surveyed in this study divided into the 21 INAPA and 40 Peace Corps systems. The table suggests that the general system profiles for INAPA and PC systems are similar. The most common service level in both systems is the "patio connection" or a singular tap stand located outside of the home (77% INAPA and 68% PC). These statistics corroborate national estimates of 70% coverage in rural areas (outside of home) (ENDESA, 2007).

It is important to note that the objective of this research was not to compare INAPA and Peace Corps systems but rather to obtain a representative sample of the types of systems constructed in the Dominican Republic. However, as mentioned earlier, INAPA and PC play different roles within RWS sector. As a political entity with default jurisdiction within the RWS field, INAPA focuses on larger systems trying to stretch limited funds to the greatest number of people. The goals and means of Peace Corps are different and facilitate working in smaller communities.

Differences in the average number of connections, total system cost, connection fees, and other general parameters reflect the dissimilarity in project design and execution between INAPA and PC and do not necessarily reflect deficiencies in system performance or community management. Table 20 highlights interesting differences between INAPA and PC systems in the perception of water quality and reported prevalence of water related illness, despite relatively similar levels in sanitation coverage (~95%). Access to hygiene education and medical treatment is one possible explanation for this disparity. These are a result of differences in educational opportunities (communities with primary schools- 81% INAPA, 67% PC) and medical facilities (communities with rural clinics 43% INAPA, 22% PC). Due to these differences, the results will break out data for INAPA and Peace Corps and also present results for the 61 total communities.

Table 20: General Profile and Results of INAPA and Peace Corps systems surveyed.

	INAPA (21)		Peace Corps (40)	
	Average	Standard Deviation or (Median)	Average	Standard Deviation or (Median)
Physical Description				
Number of Connections	106	70.8	59.7	44.9
System age (years)	5	2.7	6.85	3.5
Service Level				
Public or shared taps	1%	2%	6%	18%
Patio connections	77%	34%	68%	39%
Household connections	9%	21%	8%	19%
Multiple connections	14%	28%	18%	31%
Status of the Systems				
# days week with water	5.7	2.0	6.2	0.9
# hours per day with water	11.4	9.5	16.6	5.7
Systems with major repairs (1+ days in last month)	80%		45%	
Respondents….				
Satisfied with the service	87%		87%	
Believe service is equitable	94%		86%	
Quantity of water is sufficient	92%		74%	
Quality of water is appropriate	79%		80%	
Believe community's health is better after system	89%		88%	
% Household with diarrhea, skin/vaginal infections believed to be water related.	18%		37%	
Financial				
Connection fee (USD)*	$4.15	$4.91	$4.85	$5.60
Maximum connection fee*	$343		$15	
Minimum connection fee*	$2		$0	
Payment level (connection fee)	74%	41%	52%	50%
Tariff (USD)	$1.49	$0.73	$0.50	$0.38
Payment level (tariff)	61%	31%	53%	41%
% Respondents current in water tariff payments	71%		65%	
Bank Account Balance (USD)	$1,205	$2,145	$994	$245
% who said water committee gives financial reports	52%		43%	
* Does not include in-kind contributions				
Administration				
Frequency of committee meetings (# times/year)	7.3	(12)	7.6	(0)

	INAPA (21)		Peace Corps (40)	
	Average	Standard Deviation or (Median)	Average	Standard Deviation or (Median)
% attendance	40%	36%	37%	43%
Frequency of community meetings (# times/year)	4.2	(2)	6.6	(3)
% attendance	47%	37%	25%	28%
% water committees that cited problems with…				
Collecting the tariff	48%		60%	
Accounting	10%		25%	
Organizing meetings	14%		38%	
Physical Repairs	29%		10%	
Technical/Knowledge/capacity	14%		3%	
Partitioning of water within community	10%		3%	

8.2 Sustainability Scores

The total sustainability score as well as the SU, SP, and SL rankings for each of the eight indicator categories for each of the 61 communities can be found in Table 21. Transferring the SU, SP, and SL thresholds to the total sustainability score means that a score of less than 33% is SU, from 33% to 66% is SP, and above 66% is SL. This is the designation used in the grouped relative frequency histograms

Table 21: Total Sustainability Score and Individual Indictor Category Ratings (Sustainability Unlikely = 0, Sustainability Possible = 0.5, and Sustainability Likely = 1). Scores are for all 61 communities (continued on next page).

Name(s) of community	Activity Level	Participation	Governance	Willingness to Pay	Accounting	Financial Durability	Repair Service	System Function	Sustainability Score
La Lanza/Los Lirios	0	0	0	0	0	0	0	0	0%
Los Jobos	0	0	0.5	0	0.5	0	0	0	10%
La Cienaga	0.5	0	0	0	0	0	0.5	0.5	19%
La Lomota/Lidial	0	0	0	0.5	0.5	0	0	0.5	19%
Los Palmaritos	0	0	1	0	0	0	0.5	0.5	24%
El Paradero	0	0	0.5	0.5	0.5	0	0	0.5	24%
La Coraza	0	0	0	0	0.5	0	0.5	1	26%
Frias	0	0	0.5	0.5	0	0	1	0	26%

Name(s) of community	Activity Level	Participation	Governance	Willingness to Pay	Accounting	Financial Durability	Repair Service	System Function	Sustainability Score
Arroyo Colorado	0.5	0	0	0	0	0	1	0.5	26%
Los Arroyos	0	0	0	0	0	0	1	1	29%
El Jamito	1	0	0	0	0.5	0	0	1	29%
El Yaguarizo	0.5	0	0.5	0.5	1	0	0.5	0	33%
Pino de Rayo	0.5	0	0	0	0	0	1	1	33%
Pescado Bobo	0	0	0	0.5	0.5	0	0.5	1	33%
La China	0.5	1	0	0	0	0	1	0.5	36%
El Aguacate	0	0.5	0	0	0.5	0	1	1	38%
La Cruz/Demajagua	0.5	0	1	0.5	0.5	0	0.5	0.5	40%
Villa Nueva	0	0	1	1	1	0	0	0.5	40%
El Libonao	0.5	0	0.5	0.5	0.5	0	1	0.5	43%
Pinal de la Cana	0.5	0	0	0.5	1	0	1	0.5	43%
El Memiso	1	0	0	0	0.5	0	1	1	43%
Cumia Arriba	0	0	0	0.5	0.5	0.5	1	0.5	43%
La cuchilla	0.5	0	0	0	0.5	0.5	1	1	48%
La Cacata/La Penita	0	0	0.5	0.5	0.5	0.5	1	0.5	48%
Escalera Abajo	1	0	0.5	0.5	0.5	0	0.5	1	48%
Asiento de Miguel	0.5	0	0.5	0	1	0.5	0.5	1	50%
Los Lirios	1	0	0	0.5	0.5	0	1	1	50%
Las Lajas	0	0.5	1	0.5	1	0	1	0.5	52%
El Cumbi/Pueblo Chico	1	0	0.5	0.5	1	0	1	0.5	52%
Bajabonico Arriba	0	1	1	0.5	0.5	0	0.5	1	52%
La Joya de Ramon	0.5	0	0	1	0.5	0	1	1	52%
Arroyo Lucas	0.5	0	0	1	0.5	0.5	1	0.5	55%
Los Caraballos	0.5	0	0.5	1	1	0	0.5	1	55%
Guazaral	0.5	0	0.5	0.5	1	0	1	1	55%
Paso de La Perra	0.5	0	0	1	0.5	0.5	0.5	1	55%
Callejon y los Senos	1	0	0	0.5	1	0.5	1	0.5	57%
Mata de Café	1	0	0	1	0.5	0	1	1	57%
Las Barrenas	0.5	0.5	0	0.5	0.5	0.5	1	1	60%
Alejandro Bass	1	0	0.5	0.5	0	0.5	1	1	60%
Pananao	0	0	0.5	1	1	0.5	0.5	1	60%
Laguna Grande	1	0	1	0.5	0.5	0	1	1	60%
La Canela	1	0.5	0	0.5	1	0.5	1	0.5	62%
Los Campeches	1	1	0.5	0	1	0	1	1	62%
Angostura	0.5	0	0.5	1	1	0	1	1	62%

Name(s) of community	Activity Level	Participation	Governance	Willingness to Pay	Accounting	Financial Durability	Repair Service	System Function	Sustainability Score
Reparadero	1	1	0.5	0.5	1	0.5	0.5	0.5	64%
La Mora	1	0	0	0.5	1	0.5	1	1	64%
Sabana de la Loma	0	0	0.5	0.5	0.5	1	1	1	64%
Marmolejos	1	1	0.5	0.5	0.5	0.5	1	0.5	67%
Batey 9	0.5	1	0.5	0.5	1	0.5	1	0.5	67%
Guaranal, Quita Sueno	1	0	0.5	0.5	0.5	1	0.5	1	67%
Aguas Negras	1	1	0.5	0.5	0	0.5	1	1	69%
Batey 35	0.5	0.5	0.5	0.5	1	1	1	0.5	71%
El Gauyabo	0.5	1	0.5	0.5	0.5	1	1	0.5	71%
La Vereda	1	0	0.5	1	1	1	0	1	71%
Salamanca	1	0	1	0.5	1	0.5	1	1	74%
Ceibet de Bonet	0.5	0.5	0.5	1	1	0.5	1	1	76%
Higuero	1	0	1	1	0.5	0.5	1	1	76%
La Parcela/ El Salto	1	0	0.5	1	1	1	0.5	1	79%
INOA	1	0	1	1	0.5	1	0.5	1	79%
Los Memisos	1	0	0	1	1	1	1	1	81%
Los Rurales	1	0	1	1	1	0.5	1	1	81%

Grouped relative frequency histograms for the sustainability scores of all systems (Figure 20), INAPA systems (Figure 21) and Peace Corps systems (Figure 22) are presented below. It is important to note that an overall assessment of "sustainability likely" does not mean that sustainability is guaranteed, nor does an overall assessment of "sustainability unlikely" mean that it is impossible.

The Sustainability Analysis Tool is based on literature in the RWS field, best practices within the Dominican Republic, and the author's experience as a Peace Corps Volunteer. It is intended to be used as a diagnostic tool for development organizations to identify communities that are in need of further training. This has particular importance for ranking communities according to the level of their need, in order to prioritize training and support activities. It can also be applied to determine for any specific community what needs are most urgent within the indicator categories (e.g.

Peace Corps systems performed lowest in Participation and Finance while INAPA systems' Participation and Governance were lowest). This information is useful to development organizations for strategic planning, but can also used by user (CM) associations as an "auto-assessment" in order to identify the most appropriate support organization or agency to meet the association's (or specific community's) needs.

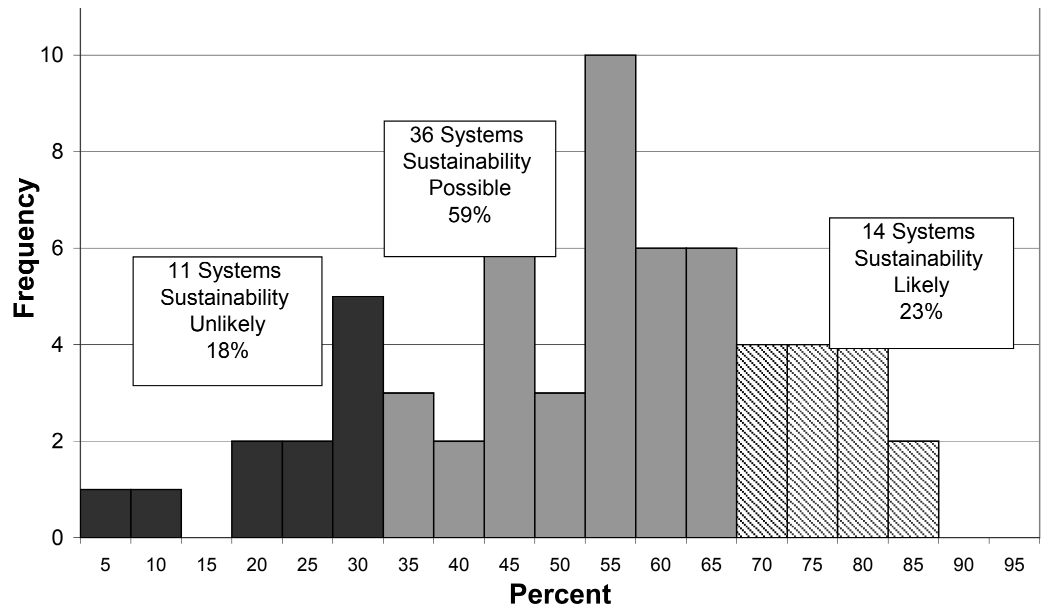

Figure 20: Overall Sustainability Score Frequency Histogram of 61 Communities included in the study.

Using the definition of sustainability developed at the outset of the thesis, the concern for the systems that are deemed "sustainability unlikely" is that service levels will not be maintained and the benefits will not be sufficient and equitable amongst the populations served. For example, communities that fair poorly in the participation, governance, and activity levels might be at a high risk for inequitable access amongst different socio-economic classes (if one group has greater influence over decision making). According to the thresholds established in this research, 11 out of 61 of the systems or 18 % (See Figure 21) are unlikely to be sustainable (SU).

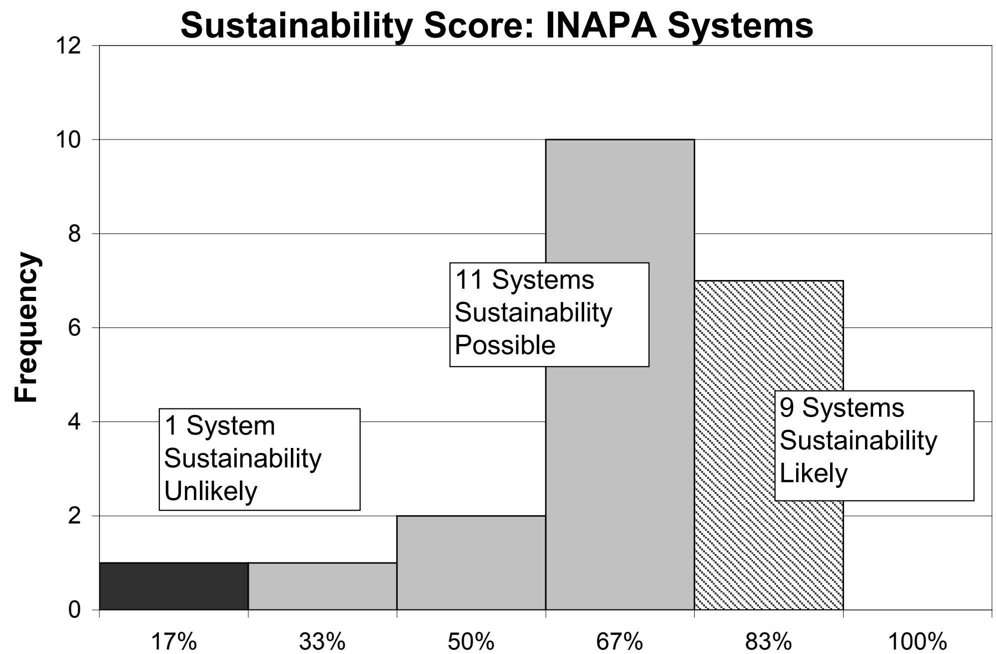

Figure 21: Sustainability Score Histogram: 21 INAPA Systems

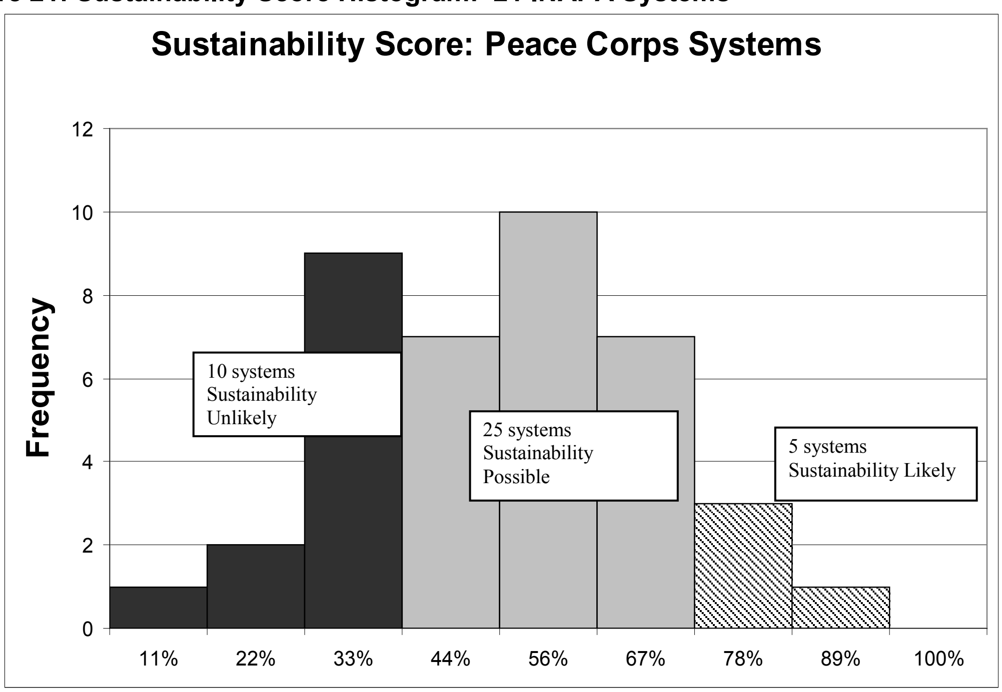

Figure 22: Sustainability Score Histogram: 40 Peace Corps Systems

8.3 Validating the Analysis

The results of the Sustainability Analysis Tool were validated using numerous objective sources: existing data from INAPA and Peace Corps (internal evaluations, monitoring reports, databases, and presentations) and data collected during the research from key informants.

8.3.1 INAPA and Peace Corps Documentation

Figure 21 illustrates the distribution of the overall sustainability assessment scores for the 21 INAPA systems surveyed. These results can be compared to findings presented in an annual presentation by AECI in 2008, in which two communities were recognized for successful community management. Los Memisos and La Parcela/El Salto (the two highest sustainability scores refer to Table 21) were cited by AECI for efficient administration, self management, and development (Reyes, 2008). These communities have, in general, more diversified and greater incomes including unique economic factors, whereby a significant portion of incomes in the community is generated through remittances from the U.S. or the tourism industry. Three communities with high sustainability scores (La Parcela, Cieba de Bonet and INOA) were also mentioned in the AECI presentation for successes in court cases, effective response to natural disasters, and for the participation in other development projects.

The results of INAPA-AR's 2006 "Evaluation of the Service of ASOCARs" validated the sustainability scores (listed in parenthesis) for 7 communities reported as functioning "regularly": INOA (79%), Batey 35 (71%), Marmolejos (67%), Reparadero (64%), Las Barrenas (60%), Callejón de los Senos (57%), Arroyo Lucas (55%). In addition, INOA received special commendation as one of the strongest community management organizations that has undergone INAPA's decentralization process.

There is also an information management database used by Peace Corps volunteers to track the progress RWS and water committees in the Healthy Environments Program. The database contains a large amount of qualitative data that was used to triangulate the sustainability scores calculated in this research. For all 19 of the systems with scores of 50% or higher, the comments recorded in the "water committee status" and "O and M" data fields were overwhelmingly positive. Similarly, many of the communities that faired poorly in the analysis also had negative remarks in the database. Examples of the commentaries are included in Table 22.

Table 22: Field Observations Validating Total Sustainability Score

Community	Sustainability/Applicable Indicator Scores	Commentary
Cruce de Pescado Bobo	33% Activity/Participation –SU Financial Durability-SU	Community is disorganized and relies on two main people. Little discipline or cooperation. Low financial compliance
La Cruz, Demajagua	41% System Function-SP Financial Durability-SU Repair Service-SP	System functions, no organization. Technical knowledge, but poor financial commitment.
Laguna Grande	60% Participation SP Repair Service-SL	Strong community, common spirit. Plumbers active and competent
Angostura	62% Repair Service-SL Activity/Governance-SP	Accomplished plumber. Competent administration. Can handle any problem

8.3.2 Primary Research Data

In addition to the non-parametric correlation tests used to verify the indicator thresholds (See Section 7.2.3), linear regression was used to validate the sustainability score of the sample communities. A regression analysis was utilized to determine the correlation between the sustainability score of a community and the cumulative number of positive responses to Question #2.7 on the Key Informant Survey (See Appendix A.3). INAPA supervisors and Peace Corps Volunteers (or database values used if the author was not able to reach the volunteer) were asked what difficulties the water committee experienced. Binary (Y/N) data was given for the following categories: delinquency, accounting, organizing meetings, physical repairs, technical knowledge/capacity, and partitioning of water within community. The total response score for Q#2.7 assumes equal weight to each category (total # out of six possible points), and the Sustainability Score uses Lockwood's weighting factors (see Section 7.2.4). Figure 23 reveals the linear trend between aggregate score for Q#2.7 and the sustainability score. Statistically, approximately seventy percent of the variation in the sustainability score can be explained by the total responses #Q2.7 "explanatory variable." The negative correlation confirms the hypothesis that as the number of difficulties reported by objective key informants increased the sustainability score decreased.

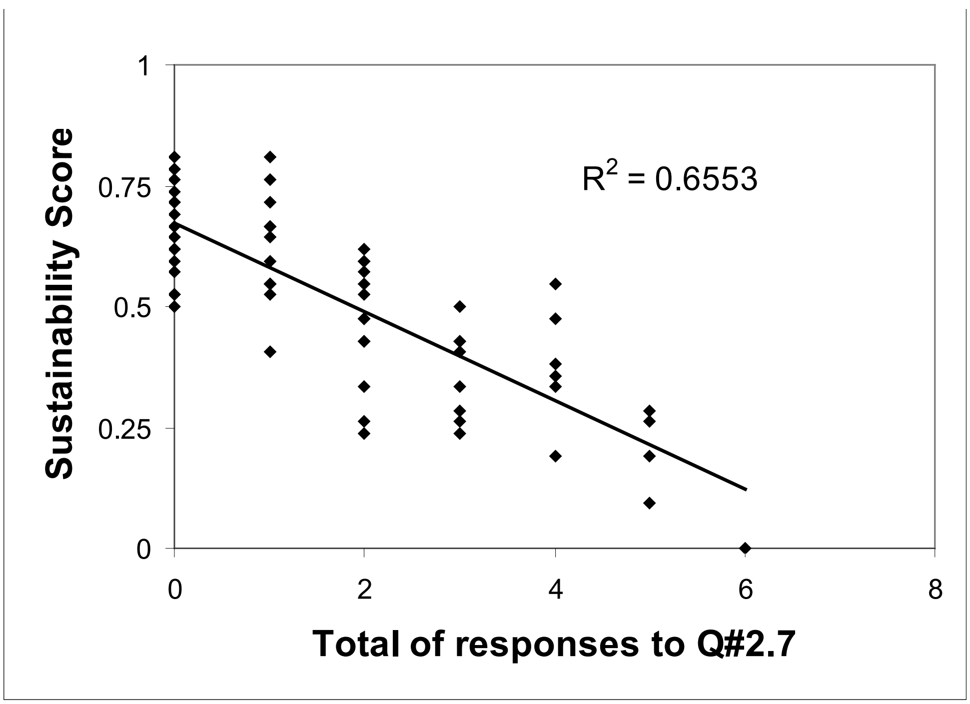

Figure 23: Linear Regression of Reported Difficulties Verses Sustainability Score

8.4 Conclusions

The rural water sector in the Dominican Republic is plagued by common problems affecting countries worldwide. Government agencies are struggling with limited resources and, meanwhile, are challenged with an increased burden on urban and peri-urban systems causing focus to be turned away from RWS. There is a strong focus on the construction of new infrastructure, insufficient spending on post construction support, and a lack of cooperation between government, NGOs, and other actors in RWS. Although INAPA is the agency with default jurisdiction in the RWS, there is no oversight or coordination with other agencies. Over two thirds of the RWS connections in the country are managed by the government (INAPA). For the other systems, the nature and extent of post construction support provided to the managers unknown. In the case of Peace Corps, ISM is equivalent to biennial visits or regional water meetings.

The sustainability analysis tool developed in this research has determined that 18% of RWS in the DR have conditions whereby the organizational, administrative, and technical capacities of the community are unacceptable, the resources (financial and material) are not available when needed or are insufficient, and the technical skills of the personnel are unacceptable for maintenance demanded (SU). Only 23% of systems have organizational, administrative, and technical capacities that are significant, resources (financial and material) that are available when needed and sufficient for the most expensive maintenance processes. In these systems the service levels and participation are reflective of a well functioning system and therefore it is believed they will likely be sustainable (SL). The remaining 59% of systems were determined to be possibly sustainable (SP), with organizational, administrative, and technical capacities falling somewhere between sufficient and insufficient.

INAPA has admitted to lacking a clear service model or action plan. The Social Promotions of INAPA-AR, the section in charge of decentralization and post construction support, does not receive sufficient funding or administrative support.

INAPA officials recognize that the decentralization process "has not advanced at the necessary rate because it has never been an institutional priority" (Rodriguez, 2008). Other obstacles to success include: lack of information, data storage and processing, low institutional memory. These obstacles plague not only INAPA but Peace Corps as well, which experiences 50% volunteer turnover every year. There is a significant difference between the sustainability of Peace Corps and INAPA systems. Although at this time it is unclear what the difference can be attributed to, one key difference is the level of post construction support (PCS). The sustainability analysis tool and the example framework established by this research can be utilized to investigate the impacts of post construction support and other important factors on sustainability of rural water systems in the Dominican Republic. This research was the first step in indentifying the proper adjusts that need to be made to ensure the sustainability of RWS.

8.5 Recommendations

8.5.1 Post Construction Support

The Sustainability Analysis Tool indicates that two-thirds of systems in operation in the DR are probably sustainable or likely sustainable. Recent literature in the RWS field has emphasized the importance of post construction support and the institutional mechanisms necessary to create a proper enabling environment and ensure continual service levels (Lockwood 2003 and 2009, Mathews 2005, and Kolesar *et al* 2004).

This study showed that a larger proportion of PC systems are considered unsustainable (SU) as compared to INAPA and one possible explanation is the differing levels of post construction support (PCS) provided by both organizations. The institutional framework in the PC Health Environments Program is heavily dependent on highly intense participatory training over a short time period (2 years of the volunteer's service), and afterwards there is very little beyond infrequent (annual or biennial) regional "water congresses." This, combined with appropriate technology interventions (gravity-fed systems), is the substitute for long term follow-up. INAPA makes nearly twenty times more visits to communities than PC (8.4 versus 0.5 visits/year). Field observations from USAID studies in the DR regarding cost recovery and tariff compliance supports the importance of PCS: "The best performance on cost recovery is found in recently reformed systems, regardless of their level of decentralization; reorganizing appears to engender a phase of institutional vitality" (Walker, 1999).

At the outset of the research it was believed that, as the level of post construction support provided to a community increases, the probability of being sustainable would as well, an idea supported by other studies. However, insufficient data was collected surrounding the nature of the follow-up visits (e.g. whether each individual visit was a routine or random visit initiated by the support organization or if it was a requested visit filling a specific need of the community). Detailed data on post-construction follow-up such as institutional "supply" verses community need or "demand" for these services is necessary in order to determine a specific correlation. Figure 24 shows a plot of number of follow up visits and system sustainability and although there is a general positive trend no correlation can be determined. The number of visits per year is only one component of post construction support. There are other variables that affect the number of visits (primarily distance from the capital and road access conditions) and to effectively measure the effects of post construction support it is necessary to identify programs that provide more systematic PCS. No trends can be determined from the figure because the majority of data points represent little or no PCS (close to the y axis).

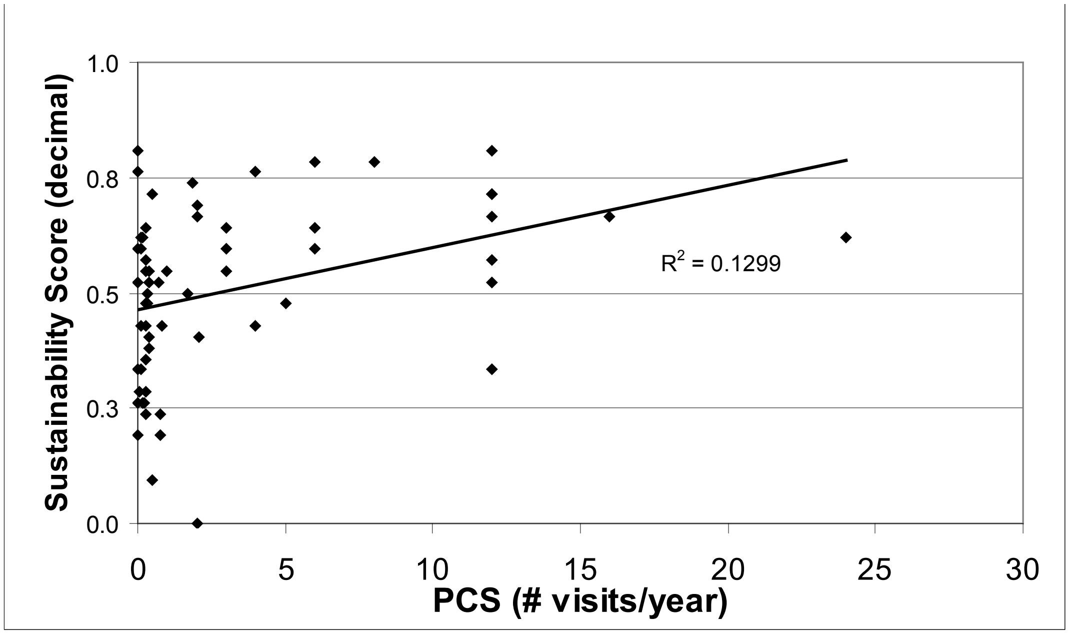

Figure 24: Relationship between Sustainability Score and Post Construction Support (measured by the number of follow up visits per year).

In order to facilitate a more in-depth evaluation of the effects of PCS it is necessary to collect more detailed data. In the author's experience, often there are situations were a community needs the presence of an outside organization to motivate the "marginal participants" in the community-those with the means to participate but lacking sufficient self motivation. Future research could establish the specific parameters for the ideal post construction support model to meet the needs and requirements specific to rural communities in the Dominican Republic.

There are many opportunities to investigate further exactly what components of post construction support are most important in the Dominican Republic and also the different roles or institutional support mechanisms that can be used to ensure that water services are equitable and sufficient. For purposes of this research the assumption was made, consistent with other streamlined analysis tools that measuring the critical dependent indicators would account for the effects of all other factors both internal and external (listed in Table 14). Research into the correlation of these factors with the sustainability of systems (as defined by this or other sustainability analysis tools) could provide important data. This information can be used for strategic planning, policy improvement, institutional strengthening, or developing cross-sectoral partnerships to improve post construction support to communities.

8.5.2 Gender and Environmental Factors Future Research

Due to time constraints, the secondary analysis described in section 8.5.1 was not conducted. A number of factors were should be included in such an analysis in the future such as gender and environmental factors. There is significant information indentifying the importance of including women in water, sanitation, and health interventions. However, in the investigation of over 70 documents on project sustainability Lockwood (2003) found that the involvement of women was "of less critical importance" than many other factors.

There have been no detailed studies that identify the specific influence that gender participation plays in RWS sustainability in the Dominican Republic. Both Peace Corps and INAPA have gender specific participation goals not requirements) however, in many cases these guidelines are not followed. INAPA specify a minimum number of women (3 out of 7-43%) and Peace Corps recommends equal representation, but gender participation is significantly lower-32%. In addition, the nature of this participation is considerably different between men and women. Men often have the more prominent roles (president-75% and vice president-71%) or roles that are consistent with their traditional sphere of responsibly (100% of plumbers and operators surveyed were men). Women, on the other hand, often assume "token" roles such as vocal or secretary, which have little or no responsibility. Furthermore, the percentage of women on the water committee that are active is less than the percent of men who are active (26% versus 39%). Future research could investigate how sustainability is correlated to different variables such as: gender roles/responsibilities on the water committee, gender focused training methodologies, and number of active people and participation by women.

Water Source production, quality, and conservation were gauged to be of critical importance by Lockwood (2nd highest ranking). For purposes of this research the indicator was not included in the analysis tool, and was assumed to be embodied in the Service Function indicator. The assumption is that the demand volumes used by both Peace Corps and INAPA in system design (20 and 25 gallons per person respectively) account for an insignificant volume of water since the communities in the study had populations less than 2,000 people. This is equivalent to a spring or other water source that produces a maximum 35 gallons per minute all day long. Although the assumption is that such a volume is insignificant, the actual environmental impacts were investigated. Future research could evaluate what the actual usage is, how the environment is affected, and how both these impact system sustainability.

8.5.3 Future Research

One possible direction for future research would be to develop, using computer modeling, an interactive software. Such software could analyze, through inferential statistics, the correlation between the all the critical parameters mentioned in this research and in the field of RWS. Criticism exists regarding the utility of, and risks associated with, prescriptive approaches and statistical methods to planning and evaluation. In development it is important to recognize the unique qualities of each community and situation. However, the author believes that in a small scale situation like that of the Dominican Republic, the benefits of creating a useful tool (such as interactive software) outweigh the risks. Such a tool would identify the relative importance of each indicator within the DR and would be helpful to development organizations, policy makers, and communities.

9 References Cited

Abrams, L. J. 1998. *Understanding sustainability of local water services*. Paper presented at 25th WEDC Conference. Addis Ababa, Ethiopia. Retrieved April 12, 2001, http://wn.apc.org/afwater/Sustainability.html

Abreu Urenia, Rosa. 1996. *Problemática Relativa al Consumo de Agua Sin Minerales en la Republica Dominicana.* Pan American Health Organization. Dominican Republic. May, 1996.

Abreu Urenia, R. 1999. *Global Assessment of the Potable Water and Sanitation Services 2000.* Pan American Health Organization. Dominican Republic.

Abreu Urenia, R. 2000. *Informe Analítico República Dominicana: Evaluación global de los servicios de agua potable y saneamiento.* United Nations Children's Fund Report. December, 2000. Santo Domingo, Dominican Republic.

Annis, John. 2006. "Assessing progress of community managed gravity flow water supply systems using rapid rural appraisal in the Ikongo District, Madagascar." Masters of Science in Environmental Engineering Report, Michigan Technological University. Houghton, Michigan. Retrieved April 25, 2009 http://cee.eng.usf.edu/peacecorps/resources.

AECI. 2001. *Programa de Agua Potable y Saneamiento en Zonas Rurales*. Agencia Española de Cooperación Internacional-Embajada Española y INAPA. Santo Domingo, Dominican Republic.

Black M.. 1998. *Learning what works: twenty year retrospective view on international water and sanitation cooperation.* United Nations Development Programme-World Bank.

Blair, Clifford R., and Taylor, Richard A. 2008. *Biostatistics for the Health Sciences.* Pearson Prentice Hall New Jersey.

BNWP. 2009. *Project No. 007: Follow-Up Support to Communities after Construction of Rural Water Supply and Sanitation Facilities; three country case study: Peru, Ghana and Bolivia.* Bank-Netherlands Water Partnership. As cited by Lockwood, 2003.

Briscoe, J. and DeFerranti, D.. 1988. "Water for Rural Communities: Helping People Help Themselves." World Bank Report. Washington D.C., USA.

Brown, G.A.. 1983. "The scale of the world problem." Presented at World Water '83, International Water and Sanitation Congress. Institution of Civil Engineers Conference report. London, UK., Thomas Telford Ltd.

Carter R.C., Tyrrel, S., and Howsam, P.. 1993. *Lessons Learned from the UN Water Decade.* Journal of Integrated Water and Environmental Managers, London, United Kingdom. 646 – 650.

CEPIS 2003. *Análisis del sector de agua potable y saneamiento en la Republica Dominicana*, Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente. Available at www.cepis.ops-oms.org.

Churchill, A., De Ferranti, D., Roche, R., Tager, C., Walters, A. and Yazer, A.. 1987. "Rural Water Supply and Sanitation: Time for a Change." World Bank Discussion Paper 18., World Bank. Washington D.C., USA.

CIA. 2002. *Central America and Caribbean 2002*. Central Intelligence Agency. Washington, D.C. obtained from online catalog of Library of Congress Geography and Map Division Washington, D.C. call # G4800 2002 .U5. Retrieved on April 15, 2009 http://www.loc.gov/rr/geogmap/gmpage.html.

CIA. 2004. *Dominican Republic 2004.* Central Intelligence Agency. Washington, D.C. Obtained from online catalog of Library of Congress Geography and Map Division Washington, D.C. call # G4951.F7 2004 .U5. Retrieved on April 15, 2009. http://www.loc.gov/rr/geogmap/gmpage.html

CIA Factbook. 2009. *Dominican Flag.* Central Intelligence Agency. Retrieved on March 12, 2009. https://www.cia.gov/library/publications/the-world-factbook/flags/dr-flag.html

DFID. 2000. *Sustainable Livelihoods Guidance Sheets.* Department for International Development, February 2000.

Dominguez, Mari. Personal interview. 24 June 2008.

ENDESA. 2007. *Características de los Hogares y de la Población 2007.* Encuesta Demografica de Salud (ENDESA). Santo Domingo, Dominican Republic.

ENHOGAR. 2006. Encuesta Nacional de Hogares de Propósitos Múltiples-2006. Oficina Nacional de Estadisticas. Santo Domingo, Republica Dominicana.

Esrey, S., Potash, J. B., Roberts, L., and Shiff, C. 1990. *Health benefits from improvements in water supply and sanitation: Survey and analysis of the literature on selected diseases*. United States Agency for International Development, Water and Sanitation for Health (WASH) Technical Report No 66, USAID. Washington DC, USA.

Grober, Ulrich. 2007. *Deep roots –A conceptual history of 'sustainable development' (Nachhaltigkeit)* Wissenschaftszentrum Berlin für Sozialforschung (WZB). February 2007. Beim Präsidenten Emeriti Projekte.

Google. 2009. Google Earth Maps. Maps created in Google Earth using data collected by author and reprinted here in accordance with Terms of Use. Retrieved on March 12, 2009. http://www.google.com/permissions/geoguidelines.html

Guy, Howard. 2003. *Domestic Water Quality, Service Level, and Health.* World Health Organization. Geneva, Switzerland.

Harvey P.A., Reed R.A. and Skinner B.H. 2002. *Guidelines for Sustainable Handpump Projects in Africa.* Interim Report, WEDC, October 2002.

INAPA-UEAR. 2007. *Estrategia de Descentralización de Acueductos Rurales.* INAPA, Santo Domingo, Republica Dominicana.

INAPA. 2000. *Breve Reseña Histórica*. Instituto Nacional de Agua Potable y Alcantarillado (INAPA). Santo Domingo, Dominican Republic.

INAPA. 2008. "Proyecto Decentralization de Acueductos Rurales-Reglamentos para la interrelación del INAPA con las ASOCARs" Internal publication for opertions. INAPA, Santo Domingo, Republica Dominicana.

INDRHI/OEA. 1994. *Plan Nacional de Ordenamiento de los Recursos Hidráulicos, Balance Hidrológico*. Instituto Nacional de Recursos Hidricos. Santo Domingo, República Dominicana.

IRC Thematic Group Scaling Up. 2005. *Scaling Up Rural Water Supply: A framework for achieving sustainable universal coverage through community management.* Community Management of Rural Water Supply Version 1, 13 August, 2005. Retrieved December 2, 2008 http://www.scalingup.watsan.net/page/187.

Isham, J., Narayann, D., and Pritchett, L. 1995. "Does Participation Improve Performance? Establishing Causality with Subjective Data." *The World Bank Economic Review*, Vol. 9, No. 2 (May, 1995), pp. 175-200.

Jimenez, Juan, Pardo, Claudia, and Reyes, Esther. 2006. *La Construcción de Acueductos Rurales y Su Impacto en el Desarrollo Humano de la Republica Dominicana una Perspectativa de Genero*. Naciones Unidas-Programa de Desarrollo, junio 27 de 2006. Santo Domingo, Republica Dominicana.

Jolly, R. 2004. *Ahead of the curve: why the UN needs the Capacity to think; UN reform: why? what? how?* 26 May 2004. London, England, UK, House of Commons. Lecture cited by (Brian Mathews, 2005).

Johnson, E and Perez E.A. 2002. "Creating an Enabling Environment for Community-Based Rural Water Supply, Sanitation and Hygiene Promotion Systems Case Study: Reforming the Rural Department of the National Water Agency (INAPA) in the Dominican Republic", Strategic Report 4. EHP, June 2002.

Kaliba, Aloce, R. M., and Norman, David W. 2009. "Assessing Sustainabilty of Community-Based Water Utility Projects in Central Tanzania with the Help of Canonical Correlation Analysis." Submission to *Journal of Environmental Assessment Policy and Management*. Retrieved on February 16, 2009, <http://www.uaex.edu/akaliba/Documents/p01_1~1.pdf>.

Karp, Andrew, and Daane, Janelle. *Dominican Republic: Evaluation of Rural Water and Sanitation Infrastructure Construction.* USAID Environmental Health Project Activity Report Number 70. June, 1999.

Leon, Miguel. "Healthy Environment Project Plan 517-HE-02." Peace Corps Dominican Republic, July 23, 2001. Santo Domingo, Dominican Republic.

Linares, Carlos, and Rosenweig, Fred. *Decentralization of Water Supply and Sanitation Services in El Salvador.* United Statnes Agency for International Development Environmetal Health Programme Activity Report. Washington D.C.. May 1999

Lizardo, Jefrey. 2005. "El Gasto Social en La Republica Dominicana 1995-2005: Tendencias y Desafios." Unidad de Análisis Económico Secretariado Técnico de la Presidencia. Serie Texto de Discusión No. 2 Junio, 2005, Santo Domingo, Republica Dominicana.

Lockwood, Harold. 2001. *Operations and Maintenance Strategy for Community-Managed Rural Water Supply Systems in the Dominican Republic.* United States Agency for International Development Environmental Health Project Activity Report 105. October, 2001. Arlington, VA.

Lockwood, H. et al. 2001. *Nicaragua: rural water supply sanitation and environmental health program.* United States Agency for International Development Environmental Health Project Activity Report 106, December 2001. Arlington, VA.

Lockwood, Harold. 2002. *Institutional Support Mechanisms for Community-managed Rural Water Supply & Sanitation Systems in Latin America* United States Agency for International Development Environmental Health Project -Strategic Report 6. December 2002. Arlington, VA.

Lockwood, Harold. 2002. "A Strategy for Operation and Maintenance of Rural Water Supplies, Dominican Republic." *Waterlines*, Vol. 21, No. 2, 22-24.

Lockwood, Harold. 2003. Post-Project Sustainability: Follow-up Support to Communities Literature and Desk Review of RWSS Project Documents. Final Report to World Bank.

Lockwood, Harold. 2004. *Scaling Up Community Management of Rural Water Supply.* Thematic Overview Paper, International Water and Sanitation Center-IRC. Delft, Netherlands. March 2004.

Lockwood, H., Moriarty, P., and Schouten, T. 2009. "Sustainable Service at Scale A multi-country learning project to improve rural water service delivery." Project Summary, IRC International Water and Sanitation Center- IRC. Delft, Netherlands. January 2009

Lockwood, Harold. Personal communication with author. 16 February, 2009.

Kolessar, R., Kleinau, E., Torres, M.P., Gil, C., de la Cruz, V., and Post, M. 2004. "Combining Hygiene Behavior Change with Water and Sanitation: Monitoring Progress in Hato Mayor, Dominican Republic." Activity Report 137 Part II, USAID Environmental Health Project. Santo Domingo, Dominican Republic. June 2004.

Mathew, Brian. 2005 "Ensuring Sustained Beneficial Outcomes for Water and Sanitation Programmes in the Developing World." Occasional Paper Series 40. International Water and Sanitation Centre-IRC. Delft, the Netherlands.

McCommon, Carolyn, Warner, David, and Yohalen, David. 1990. *Community Management of Rural Water Supply and Sanitation Services*, UNDP-World Bank, Washington D.C., USA.

McConnville, Jennifer R and Mihelcic, James R. 2007. "Adapting Life-Cycle Thinking Tools to Evaluate Project Sustainability in International Water and Sanitation Development Work." *Environmental Engineering Sciences,* Vol. 24, No. 7, pp 937-948.

Morillo Perez, A., Guerrero Arias, A.,and Alcantara Rosario, Y. 2005. *Focalizacion de la Pobreza el la Republic Dominicana 2005*. Sectretariado Tecnico de la Presidencia. Santo Domingo, julio de 2005.

MacDonal, Mott. 1999. *Proyecto de Consolidación de la Reforma del Sector de Agua Potable y Saneamiento – República Dominicana.* Anexo B – Estudio de Oferta y Demanda de Agua Potable y Saneamiento, Banco Internacional de Desarrollo- BID.

Moya Pons, Frank. 1998. *The Dominican Republic: A National History.* Markus Weiner, Princeton, NJ.

Mukherjee N. and van Wijk C. editors. 2003. *Sustainability Planning and Monitoring in Community Water Supply and Sanitation.* Water and Sanitation Program-IRC. Delft, Netherlands.

Narayan, Deepa. 1995. "The Contribution of People's Participation: Evidence from 121 Rural Water Supply Projects." Environmentally Sustainable Development Occasional Paper Series No. 1, The World Bank. Washington D.C., USA.

NASA. 2004. *Flooding on Hispaniola.* National Aeronautics and Space Administration. Shuttle Radar Topography Mission. Retrieved on March 15, 2009, http://www.loc.gov/rr/geogmap/gmpage.html.

Nichols, Paul. 2000. *Social Survey Methods: A Fieldguide for Development Workers*. Development Guidelines, No. 6, Oxfam. London, United Kingdom.

Niskanen, Mathew. 2003. "The Design, Construction, and Maintenance of a Gravity Fed Water System in the Dominican Republic." Masters of Science in Environmental Engineering Report, Michigan Technological University. Houghton, Michigan, Retrieved April 25, 2009. http://www.mtu.edu/d80/resources/topic.html.

ONE. 2007. *Republica Dominicana en Cifras 2007.* Annual Statistical Report, Oficina Nacional de Estadistica-ONE. Santo Domingo, Dominican Republic.

Orr, Blair and Annis, Jonathan E. 2009. "Participatory Approaches and Community Management in Engineering Projects" Chapter 3 in *Field Guide in Environmental Engineering for Development Workers: Water, Sanitation, Indoor Air* (Mihelcic, J.R., E.A. Myre, L.M. Fry, B.D. Barkdoll., American Society of Civil Engineers (ASCE) Press, Reston, VA expected Fall 2009

Parry-Jones, Sarah. 1999. "Optimizing the selection of demand assessment techniques for water supply and sanitation projects." Project/Task No: 207, Water and Environmental Health at London and Loughborough. United Kingdom. October 1999.

Peace Corps. 2008. "Water and Sanitation Engineering Peace Corps Assignment 131." Peace Corps: Creating Sustainable Solutions. Retrieved on March 12, 2009. www.peacecorps.gov

PNUD (2000). *Informe Nacional Desarrollo Humano 2000*, Programa de las Naciones Unidas para el Desarrollo. Santo Domingo, República Dominicana.

PNUD (2008). *Informe Nacional Desarrollo Humano 2008*, Programa de las Naciones Unidas para el Desarrollo. Santo Domingo, República Dominicana.

Pratt, Brian and Loizos, Peter. 1992. *Choosing Research Methods: Data Collection for Development Workers*. Development Guidelines No. 7,Oxfam. Oxford, United Kingdom. 120p.

Reents, N. 2003. "Design of potable water supply systems in rural Honduras." Masters of Science in Environmental Engineering Report, Michigan Technological University. Houghton, Michigan, Retrieved April 25, 2009. http://www.mtu.edu/d80/resources/topic.html.

Reyes, Esther. 2008. "Instituto Nacional de Aguas Potables y Alcantarillados INAPA Descentralización de Acueductos Rurales." Presentation given to INAPA directors October, 2008.

Reyes, Esther. Personal interview. 8 December 2008.

REO. 2009. Information Center Definitions. Northwest Forest Plan (NWFP). Regional Ecosystem Office. Retrieved on March 10, 2009. www.reo.gov.

Rodriguez, Marcos. Personal interviews. 25 June 2008.

Rodriguez, Marcos. “INAPA Profile 2008” PowerPoint presentation April 24, 2008.
Operations Evaluation Department. 2003. Internal Guidelines and Criteria for OED Project Evaluations, World Bank. June 2003.

Rosensweig, Fred. editor. 2001. “Case studies on decentralisation of water supply and sanitation services in Latin America”. Strategic Paper no. 1, Environmental Health Project (EHP), January, 2001. Arlington, VA.

Sara, J. and Katz, T. 1997. *Making Rural Water Supply Sustainable: Report on the Impact of Project Rules.* Water and Sanitation Program, United Nations Development Program-World Bank. Washington D.C., USA.

Schmidt, William. 2002. “Water System Review;Lessons Learned from the field” Internal Publication, Peace Corps Dominican Republic. Santo Domingo, Dominican Republic. September 2002.

Schouten T. and Moriarty P. “From System to Service” - draft International Water and Sanitation Centre-IRC and ITDG. The Hague, Netherlands. August 2003.

Scrimshaw, Nevin S and Gleason, Gary R.. 1992. “Rapid Assessment Procedures - Qualitative Methodologies for Planning and Evaluation of Health Related Programmes,” International Nutrition Foundation for Developing Countries (INFDC). Boston, MA. USA.

SEMARN. 2006. *Objetivo del Milenio 7: Garantizar la Sostenibilidad Ambiental.* Evaluación de necesidades para la Republica Dominicana. Secretaria de Estado de Medio Ambiente y Recursos Naturales. Santo Domingo, Republica Dominicana.

Steel, Robert G. D. and Torrie, James H. 1960. *Principles and Procedures of Statistics, with Special Reference to the Biological Sciences*. McGraw-Hill Book Company Inc, New York.

Sugden, S. 2001. “Assessing Sustainability-the Sustainability Snapshot.” Paper presented at the 27^{th} WEDC Conference- Zambia, April 2001, 328-331. Retrieved January 23, 2009. http://irc-eh-field-guide.com.

UNCECSR. 2009. “The right to water (Articles. 11 and 12 of the International Covenant on Economic, Social and Cultural Rights).” The United Nations Committee for Economic, Cultural and Social Rights. Retrieved on January 23, 2009, http://www.unhchr.ch/tbs/doc.nsf/0/a5458d1d1bbd713fc1256cc400389e94/$FILE/G0340229.pdf

UNDP. 2008. *Desarrollo Humano, una Cuestion de Poder.* Informe sobre Desarrollo Humano Republica Dominicana 2008, United Nations Development Programme. Santo Domingo, Dominican Republic.

UNDP. 2006. *Beyond scarcity: Power, poverty and the global water crisis.* United Nations Development Programme Human Development Report 2006. Retrieved on April 23, 2009. http://hdr.undp.org/en/media/HDR06-complete.pdf

UNICEF. 2008. *Progress in Drinking-water and Sanitation: special focus on sanitation.* United Nations Children’s Fund. Retrieved on April 12, 2009, http://www.wssinfo.org/en/40_MDG2008.html.

United Nations. 1980. Proclamation of the International Drinking Water Supply and Sanitation Decade. New York, USA. 10 November 1980.

United Nations. 2007. *2007 Country Profile: Dominican Republic*. Commission for Sustainable Development, United Nations, New York, USA.

Urena Bravo, Carlos. 2007. *Guia de Procedimiento Administrativo para la gestión de las ASOCAR en los Acueductos Rurales.* INAPA. Santo Domingo, Republica Dominicana. June 2007,

USAID. 2006. "Evaluation of USAID Strategy to Increase Potable Water Access and Sanitation in Rural Areas Dominican Republic- Final Report." United States Agency for International Development-USAID. April 27, 2006. Research Triangle Park, NC.

Walker, Ian and Velásquez, Max. 1999. *Regional Analysis of Decentralization of Water Supply and Sanitation Services in Central America and the Dominican Republic*. Activity Report 65. United States Agency for International Development. May 1999. Research Triangle Park, NC.

Wakeman, Wendy. *Gender Issues Sourcebook for Water and Sanitation Projects.* Working Group on Gender Issues-Water and Sanitation Collaborative Council. The World Bank, January 1995. Washington, D.C., USA.

Whittington, D., Davis, J., Prokopy, L., Komives, K., Thorsten, R., Lukacs, H., Bakalian, A., and Wakeman, W. 2008. "How well is the demand-driven, community management model for rural water supply systems doing? Evidence from Bolivia, Peru, and Ghana." Brooks World Poverty Institute (BWPI) Working Paper 22, January 2008.

WHO/UNICEF. 2008. *Progress in Drinking-water and Sanitation: special focus on sanitation.* Joint Monitoring Program, 2008. World Health Organization and United Nations Childrem's Fund.

WHO/UNICEF. 2006. *Coverage Estimates: Improved Drinking Water-Dominican Republic.* Joint Monitoring Programme for Water Supply and Sanitation Updated June 2006. World Health Organization and United Nations Children's Fund. Retrieved January 20, 2009. www.wssinfo.org .

WHO. 2007. Quantification of the Disease Burden Attributable to Environmental Risk Factors. World Health Organization. Retrieved on February 12, 2009. http://www.who.int/quantifying_ehimpacts/summary_EBD.pdf

World Bank. 2005. *Informe Nacional de Desarrollo Humano: Republica Dominicana*. Santo Domingo, Republica Dominicana. Retrieved February 12, 2009. http://odh.onu.org.do/publicaciones/informenacionaldesarrollohumano2005.

WTO. 2003. "Women as Economic Players in Sustainable Development" Summary Report for CIDA Geneva Women in International Trade Session. World Trade Organization Public Symposium, 16 June 2003. Retrieved on March 17, 2009 www.wto.org/english/tratop_e/dda_e/symp03_gwit_background_e.doc

Yin, Robert, K. 2003 *Case Study Research: Design and Methods.* Third Edition. Sage Publications. Thousand Oaks, CA, 181.

10 Appendix

A.1. Peace Corps Healthy Environment: Program Goals and Objectives:

Goal No. 1:

Low-income families will improve sanitation infrastructure resulting in a reduction in the transmission of water-borne diseases.

Objective No. 1:

Train community leaders to construct gravity-flow aqueducts to increase the access of rural families to drinkable water and adequate excreta disposal system so that:

- 80% of the Water Committee leaders will be able to describe components of a small gravity-flow aqueduct and latrine;
- 50% of the families (one member) will be willing to participate in the work brigade for the construction of small aqueducts and latrines;
- 40% of the families will be participating in the construction of a small gravity flow aqueduct and latrine;

Objective No. 2:

Train community leaders to properly manage, maintain and operate the water systems and latrine constructed so that:

- 80% of the leaders able to describe the main parts of a simple operation, maintenance and management plan of an aqueduct and latrine;
- 70% of the trained leaders are able to demonstrate the correct operation of an aqueduct and latrine;
- 60% of the aqueducts and 80% of the latrines will be normally operated and maintained.

Goal No. 2

Low-income families living in the rural area will adopt improved sanitation and healthy practices through educational activities.

Objective No. 1:

Train community leaders to be sanitation facilitators so that:

- 80% of the trained leaders will be able to identify and describe 3 non-formal education techniques to teach improved sanitation;
- 50% of the trained leaders will be able to understand how they are at risk of contacting a water-born disease;
- 50% of the trained leaders will be able to demonstrate correct sanitation practices;
- 40% of the trained leaders will be training families how to improve sanitation practices.

Objective No. 2:

Reach families with messages of improved sanitation and hygiene practices so that:

- 80% of the families will be able to identify and describe the diseases transmitted through water as a result of poor environmental health conditions;
- 50% of the families will be able to identify the risk of contracting diseases;
- 50% of the families will be able to demonstrate the correct use of latrine and water;
- 40% of the families will be correctly using water and latrines.

Goal No. 3

Community leaders will be actively participating in the decision making process of designing and implementing sanitation projects;

Objective No. 1:

Train community leaders to organize Water Committees to respond to the water and sanitation needs of rural communities so that:

- 80% of the trained leaders will be able to explain the importance of community organization and participation in sanitation projects;
- 70% of the community leaders are willing to participate and serve in the Water Committees;
- 40% of the trained leaders will be able to demonstrate how to run a Water Committee;
- 20% of the trained leaders are running the Water Committees supporting the implementation of sanitation projects;

Objective No. 2:

Train Water Committee leaders to identify funding sources, articulate proposals and set operational procedures to manage sanitation projects so that:

- 80% of the trained Water Committee leaders will be able to describe 3 local funding organizations, main parts of a proposal and the controls to use donated resources;
- 40% of the trained Water Committee leaders to have the ability to manage donated resources;
- 20% of the trained Water Committee using donated resources according to basic accounting procedures.

A.1- Peace Corps' Healthy Environment (continued)

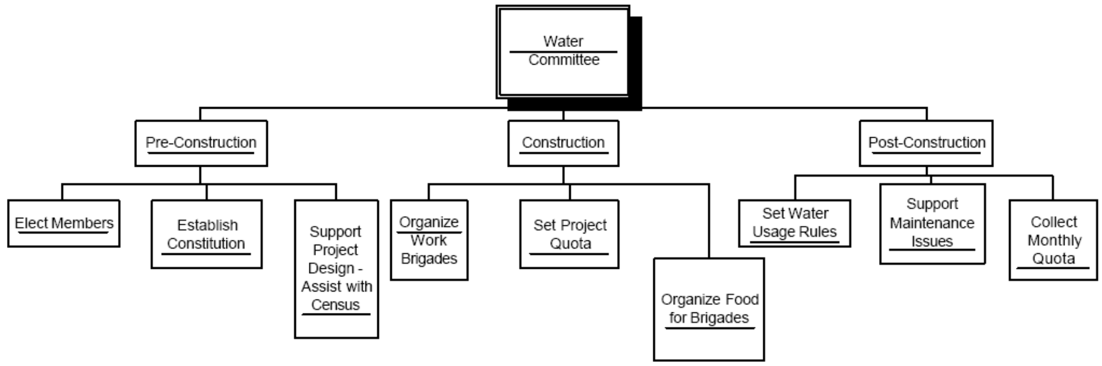

Figure A.1- An Example of the Structure and Responsibilities of the Water Committee (Niskanen, 2003).

A.2. Form for the Water Committee Focus Group Survey (Questions #1.1 - #1.50)

WATER COMMITEE FORM

Community:___	Province:___	Date:___	Initials:___

1. Water committee incorporate? YES NO (For INAPA)
2. Construction dates (month/year):
_________________ start ___________________finish
3. Committee member:

Active/ Inactive	Title	Gender M / F	Education level (# of years passed)	Occupation

4. # homes connected____ # inhabited house holds _____
5. Meeting frequency:
   Water Committee: ___________
   Community: _______________
6. What is the format of the community meeting?
   - ❑ agenda
   - ❑ moderator
   - ❑ raise hand
   - ❑ limited time
   - ❑ proposals/seconds
   - ❑ ________________
7. Average attendance at meetings:
   Water Committee: ________ people
   Community: __________ people
8. Dates of the last meetings:
   Water Committee: last________ next:__________
   Community: last__________ next:__________
9. Organizational issues:
   - ❑ Disaccord / fractioning
   - ❑ Conflict resolution
   - ❑ Equity in service within the community
   - ❑ Mismanagement/Misuse of water resources.
   - ❑ Enforcement of connection rules
   - ❑ Wasting of water
   - ❑ Sanitation/Drainage issues
10. Describe decision making process: ______________
____
11. Conflict resolution process:______________________
____
12. Number of elections executed?__________________
13. Date of the last election? ____ month ______year
14. Formed Statutes? Y N Do they function? Y N
Why?_______________________________________
15. What have been the greatest difficulties that the Water Committee has had in the O & M of the system.
   - ❑ Collecting the tariff
   - ❑ Accounting
   - ❑ Organizing meetings
   - ❑ Physical repairs
   - ❑ Technical knowledge/capacity
   - ❑ Partitioning of water within community
   - ❑ Other:_________________________________
16. Water right fee (initial payment) RD$____________
   % who paid___________
17. Amount of monthly tariff RD$ _________________
   Per: family connection
18. How was the tariff choosen? ___________________
____
19. How does water committee enforce payment?______
____
20. Who collects the tariff? ______________________
21. How much are they paid?_____________ per monthly
22. Percentage who owe 3 months or more (tariff): ____%
23. Use an accounting book? YES NO
24. Give receipts to users upon request? YES NO
25. Sanction users? YES NO RD$ ______________
26. Have you suspended service of a user? YES NO
27. How many times? _____ Reasons: ____________________
28. Bank Account? YES NO
   Balance RD$ _____________________
29. How many manage account?________
30. Whom? (put titles) ___________ ___________ _________
31. Motives, dates, and amounts of last two withdrawals?
____
32. Date of last accounting review?: _______month _____year
33. Was their an inaugural ceremony? YES NO
What was it like? (Mark only one type):
0 1 2 3 4 5
Nothing---Act---Refreshments---Food-------Party---Large Party
34. Who covered the costs?____________________________
35. How much is a full days wage with food? ________RD/day
36. Service Level:
a) public/shared taps _______% c) single tap in home_____%
b) 1 private tap in patio _____% d) multiple connections ___%
37. In last month how many days was any part of the community without water? _________ days
38. How many often is there water in the system? (on average)
____________days/week for an average of __________hrs/day
39. Is there an operator? YES NO Payment? __________
40. Is there a plumber? YES NO Payment? _________
41. How is the system functioning?
a) Very well b) Well c) Regularly d) Poorly e)Very Poorly
Comments:____
42. New connections in the last year?_____________________
43. Since completion of the aqueduct how many times have you solicited external help? _____ From whom? _______________
44. What was the form of the help?_______________________
____
45. Do you have a clorination treatment system? YES NO
46. If so, how often is it function?
a) always b) frequently c) sometimes d) rarely e)never
47. Problem areas in the water service:
   - ❑ Water intake (spring box/dam/etc)
   - ❑ Tubeline from intake to storage
   - ❑ Distribution network
   - ❑ Tank
   - ❑ Other: ____________________________________
48. Community contribution during construction:
   - ❑ Water intake (spring box/dam/etc)
   - ❑ Tube line from intake to storage
   - ❑ Distribution network
   - ❑ Tank
   - ❑ Other: ____________________________________
49. How was the work organized (# days/week and food)?
____
50. What has been the largest obstacle to the proper functioning of the water system?_________________________________
____

Notes: ____
____
____
____
____
____
____

A.3. Survey Forms for Key Informants (Questions #2.1-#2.9 and #3.1-#3.18).

OBSERVATION and PEACE CORPS DATA BASE FORM

Community:______________________________ Province:_________________________ Date:___________ Initials:_________

1. Name of municipality____________ Distance away from municipality: ________ Km.

2. Communities/Townships that benefit from the system: 1 2 3 4 5 other___________

3. Access road conditions:
a) asphalt road (GOOD) b) dirt or gravel road (OK) c) highly eroded dirt road (BAD)

4. Most common house in the community:
a) palmboard/wood walls and cane roof b) palmboard/wood walls and zinc roof c) Cement block and zinc/cement roof

5. Economic base of the community:
a) Agriculture b) Animal Husbandry c) Commercial activities d) Laborers e) Sugar cane Plantations a f) Remittances

6. Number of follow up/support visits from Peace Corps/INAPA after completion of the project: _____________

7. What have/has been the greatest difficulties that the Water Committee have/has encountered in the O & M of the system.
- ❑ Collecting the tariff
- ❑ Accounting
- ❑ Organizing meetings
- ❑ Physical repairs
- ❑ Technical knowledge/capacity
- ❑ Partitioning of water within community
- ❑ Other:__________________________________

8. How have they responded to the challenges during their administration/stewardship of the system.
a) They act independently with their own knowledge and resources.
b) With minor external assistance mainly technical or financial in the case of large repairs (pumps, suspension crossings, tanks, etc)
c) Need significant external assistance both technical and financial for regular repairs (tubes, tanks, etc).
d) Community is completely dependent on external involvement for the majority/all aspects of O and M.

9. Approximate percentage of deforestation in the watershed: _______________% deforestation

---

PLUMBER AND/OR OPERATOR FORM

Community:__________________________________ Province: ________________ Date:__________ Initials:_________

1. Gender: MALE FEMALE
2. Role: PLUMBER OPERATOR BOTH
3. Do you receive payment? YES NO
4. How much? ________________ RD/month
5. Payments: a) always/on time b)always but sometimes late c) frequent d) owed _________ months

7. Which of the following activities have you done or know how to do?
- ❑ Construct an intake structure
- ❑ Change/Install different valves
- ❑ Change/Install float valves
- ❑ Construct break pressure box
- ❑ Take apart and clean pump
- ❑ Fix all general plumbing issues
- ❑ Install specialty fixtures (universal unions/checks)

8. How often do you clean the tank (months between)?
a) >1 month b)Monthly c) 2-3 months d) Rainy season e) Never

9. Problems with service:
- ❑ Water intake (spring box/dam/etc)
- ❑ Tubeline from intake to storage
- ❑ Distribution network
- ❑ Storage Tank
- ❑ Pump

the community? ____ Reason? __________________________

11. Do you have a maintenance plan? YES NO
Do you follow it? YES NO

12. Monthly expenditures on normal maintenance materials?
____________ $RD/month

13. What is your total personal income in an average month (for farmers it is the yearly average distributed)?_______$RD/month

14. How much time do you dedicate to system operation?
_________hours/day

15. How much time do you dedicate to system maintenance
__________hours/month _______days/month

16. Have you attended a training activity or workshop on plumbing and general operation of aqueducts? YES NO

17. Relating to the activities of operation and maintenance of the system. Do you feel comfortable doing:
a) all b) most c) some d) few e) none

18. What is the greatest challenge to the proper functioning of the aqueduct?____

____

____

____

A.4. Community Survey Form (Questions #4.1 - #4.21).

Mark with: S (YES) N (NO) SR (No Response)		Respondents*										
#	Questions	1	2	3	4	5	6	7	8	9	10	11
1	Do you know if the committee meets?											
2	Do they given financial reports?											
3	Do they collect a tariff?											
4	Do conflicts exist between committee members?											
5	Are you satisfied with the service?											
6	Is the service equitable?											
7	Is there suffient water?											
8	Do people use water for non-domestic uses?											
9	Has anyone connected to the system with the committtee's authorization?											
10	Is there a problem with wasting of water?											
11	Has the committee ever used funds for anything other than the aqueduct?											
12	Do a majority of people go to community meetings?											
13	Do you know the rules outlined in the statutes?											
14	How much is a full day's wage with food (**$RD/day)**											
15	Do you have a latrine?											
16	Are you satified with the quality of the water (do you drink it)?											
17	Do you believe community health has improved as a result of construction of the water system?											
18	Are you current with your tariff payments?											
19	Do anyone in your household suffer from diarhea?											
20	Does anyone in the household suffer form skin infecions?											
21	Does anyone in the household suffer from vaginal infections?											

* Survey 10% of households utilizing the system. So for example, if there are 90 households benefitting from the water system, survey 9 and if there are 93 do 10.

A.5. Technical Data Sheet (Questions #5.1 - #5.10).

TECHNICAL IINFORMATION FORM			
Community:______________________	Province: ______________	Date:________	Initials:__________

1. Water source:
a) Well b) Spring c) River or Creek

2. Geographic coordinates (GPS) N___________ O____________

3. Service Level:
a) public/shared taps _____% c) household (single tap indoor plus yard tap) _________%
b) household (private tap in yard) ______% d) household (multiple indoor/outdoor) _____% Average # taps/home_____

4. Distance from the water source to the center of the community. _________________ minutes walking

5. Total cost of the project ____________ $RD

6. Total cost of the labor ____________$RD

7. Total materials cost ____________ $RD

8. Financed by: ____

9. Community contribution: 1) __________RD capital 2) ________________in kind value 3) ______________other

10. Initial Population _______________ Design population _______________

11. Tubeline from source to tank______________________ meters

12. Capacity of the Storage Tank______________________________ gallons or cubic mete

13. Storage Tank construction: a) reinforced concrete b) cement block c) ferrocement d) rock e) metal f)plastic

14. Sedimentation tank: YES NO

15. Community services:
- ❑ Electricity
- ❑ Elementary School (1-8)
- ❑ Secondary School (9-12)
- ❑ Rural Clinic

16. Sanitation coverage (latrine or bathroom) __________ %

A.6. Informed Consent Declaration.

Oral Informed Consent for Community Survey

This survey, on the functioning of your aqueduct, is part of a study I am doing as part of my college education. I am studying the community operation and management of rural water systems in the Dominican Republic with the purpose of identifying factors which most affect system sustainability. I would like to talk with you about your experiences and opinions with the aqueduct in your community. I hope to better understand the challenges facing communities so that in the future we can improve the training and support of communities.

I have a series of questions that I would like to ask you that will only take a short time. You were randomly chosen to participate, but you are not obligated to do so. You do not have to respond to any question if you do not want to and may stop at any time. It is possible that I will use this information in a report but all your answers will be confidential and will only be used together with other responses to obtain a general public opinion. None of your responses will affect you or your community's relationship with (**Peace Corps** or **INAPA**) and it is your decision to participate or not.

Permiso Informado Oral para la Encuesta Comunitaria

Esta encuesta es sobre el funcionamiento del acueducto en su comunidad y es parte de un estudio que estoy logrando como parte de mi educación universitaria. Estoy investigando la operación y mantenimiento comunitario de sistemas de agua en zonas rurales en la República Dominicana con la meta de identificar los factores quienes más influyen la sostenibilidad de los sistemas. Me gustaría hablar contigo sobre sus experiencias y opiniones con aspecto al acueducto comunitario. Espero entender mejor los desafíos que enfrenten las comunidades para que, en el futuro, podamos mejorar la capacitación y apoyo a las comunidades.

Tengo algunas preguntas que me gustaría hacerle y durara poco tiempo. Usted ha sido seleccionado al azar, pero no hay obligación de participar. Usted no tiene que responder a ninguna pregunta si usted no desea y se puede parar cuando usted quiera. Es posible que usare esta información en un reporte pero todas sus respuestas serán confidenciales y solo serán usadas juntas con las de más para obtener una opinión general de la comunidad. Ninguna respuesta podría afectar su relación o la de su comunidad con (**el cuerpo de paz** o **INAPA**) y la decisión de participar o no participar es solo de Usted.

Translated by Ryan Schweitzer-ACTFL (American Counsel of the Teaching of Foreign Languages) level 9 of 10.

A.7. Listing of INAPA water systems with ASOCARs.

Note: The total cohort (67 systems) used for the research reflects the total number of rural water systems with community management organizations (82 systems) removing abandoned systems or those serving populations greater than 2,000 people. The sample (23 systems) selected for evaluation are highlighted.

#	Province	Community	Population
1**	Azua	Las Lomas	1,000
2**	Bahoruco	Pie de la Loma	200
3	Barahona	Los Lirios/ La Lanza	275
4*	Barahona	Monteada Nueva	340
5	Barahona	Villa Nizao	528
6	Barahona	Las Auyamas	1,710
7	Barahona	Guazara	2,500
8	Barahona	Arroyo Arriba	
9	Dajabon	Santiago de La Cruz / Pinar Claro	2,500
10	El Seybo	Higua	135
11	El Seybo	La Parcela	150
12	El Seybo	Las Barrenas / Los Prietos	235
13	El Seybo	Reparadero	308
14	El Seybo	Marmolejos	336
15	El Seybo	La Meseta	371
16	El Seybo	Las Guajabas/ Paso Cibao	474
17	El Seybo	Altos de Peguero	500
18	El Seybo	Arroto Lucas	500
19	El Seybo	Los Bejucos	595
20	El Seybo	Cañada de la Vaca	600
21	El Seybo	Batey 35	721
22	El Seybo	Sesteadero	752
23	El Seybo	Km.6	1,499
24	El Seybo	Caciquillo	1,735
25	El Seybo	La Higuera	3,694
26	El Seybo	Los Corazones	
27	El Seybo	Sabana del Rodeo	
28	Hato Mayor	Libonao	260
29	Hato Mayor	El Bambu	308
30	Hato Mayor	La Mora	336
31	Hato Mayor	La Jaqueta	390
32	Hato Mayor	Los Vasquez	440
33	Hato Mayor	Monte Coca	790
34	Hato Mayor	Km. 20	1,071
35	Hato Mayor	Mango Limpio	1,290
36*	Hato Mayor	El Coco - fuera de Servicio	413
37*	Hato Mayor	Km. 15 - fuera de Servicio	1,080
38	Independencia	Batey 9	1,110
39	La Altagracia	Los Memisos	929
40	La Vega	La Cidra / El Caimito	4,000

#	Province	Community	Population
41	Monte Plata	Km. 5	300
42	Monte Plata	Lombrizoide	325
43	Monte Plata	Guanito	597
44	Monte Plata	El Vigia y Batey la Malla	945
45	Monte Plata	Jobo Grande	1,020
46	Monte Plata	La Parcela/ El Salto	1,183
47	Monte Plata	La Cuchilla El Porton y La Curva	1,987
48	Monte Plata	La Cuchilla-Maimon y El Naranjo	2,164
49	Monte Plata	La Guazuma	2,185
50	Pedernales	Aguas Negras	301
51	Peravia	Mencia	799
52	Peravia	Galeon	700
53	Peravia	Hondura	800
54*	Peravia	Las Tablas+G15	813
55	Peravia	Yaguarizo	900
56	Peravia	Monteria	1,050
57	Peravia	La Saona - El Mani	3,250
58	Peravia	El Llano	5,125
59	Peravia	Sombrero	7,000
60	Peravia	El Fundo	17,500
61	San Cristobal	Los Toros	365
62	San Cristobal	Los Cajuiles	535
63	San Cristobal	La Canela	875
64	San Cristobal	Hato Viejo/Los Amaceyes	885
65	San Cristobal	Kilometro 59	1,018
66	San Cristobal	Los Yagrumos	1,071
67	San Cristobal	Callejon de los Sena y Gustavo	1,330
68	San Cristobal	Guananito/Basima/Sabana Piedra	5,855
69	San Cristobal	La Jagua	
70	San Juan de la Magu	Las Yayitas	540
71	San Juan de la Magu	Pajonal	737
72	San Juan de la Magu	El Guayabo	969
73	San Juan de la Magu	Pueblo Nuevo	1,080
74	San Juan de la Magu	Cardon	1,230
75	San Juan de la Magu	Vallejuelo	11,000
76	San Pedro de Macori	Alejandro Bass	825
77	San Pedro de Macori	Antena/ Km. 14 (Laguna Prieta)	4,530
78	Sanchez Ramirez	Las Lajas	1,118
79	Santiago	Inoa	1,840
80	Santiago	La Celestina	2,200
81	Santiago	COCODESI	14,550
82	Santiago Rodriguez	Ceiba de Bonet	629

	Eliminated for population size > 2,000
	samlple community (selected randomly from province)
	selected for sample but did not participate.
*	Eliminated because system was abandoned or not functioning.
**	Unknown that system was disabled/abandoned

A.8. **List of Communities and Survey Administrators for INAPA Systems**. Only 21 of the 23 systems were surveyed. Two systems from the original sample (Pie de la Loma and Las Lomas) were excluded because it was unknown that both systems were abandoned, no committee functioned, and no reliable data could be collected.

Name(s) of community	Province	Survey Administrators
Arroyo Lucas	El Seybo	Carlos Rodríguez, Maximo , Ryan Schweitzer
Las Barrenas/ Los Prietos	El Seybo	Carlos Rodriguez, Maximo , Ryan Schweitzer
Reparadero	El Seybo	Carlos Rodríguez, Maximo , Ryan Schweitzer
Marmolejos	El Seybo	Carlos Rodríguez, Maximo , Ryan Schweitzer
Batey 35	El Seybo	Carlos Rodríguez, Maximo , Ryan Schweitzer
El Libonao	Hato Mayor	Maximo, Carmen, Ryan Schweitzer
La Mora	Hato Mayor	Maximo, Carmen, Ryan Schweitzer
Batey 9	Independencia	Alejandrina Rosa, Maximo
Los Memisos	La Altagracia	Alejandrina Rosa, Maximo, Ryan Schweitzer
La cuchilla	Monte Plata	Mari Dominguez, Carmen Ryan Schweitzer
La Parcela/ El Salto	Monte Plata	Maximo Nelly, Ryan Schweitzer
Aguas Negras	Pedernales	Charlie Requatt, Margo Mullinax, Ryan Schweitzer
El Yaguarizo	Peravia	Nelly, Maximo, Ryan Schweitzer
Callejon y los Senos	San Cristobal	Alejandrina Rosa, Maximo, Ryan Schweitzer
La Canela	San Cristobal	Carmen, Nelly, Ryan Schweitzer
El Gauyabo	San Juan de la Maguana	Juan Toledo, Maximo, Alejandrina, Ryan Schweitzer
Alejandro Bass	San Pedro de Macorix	Alejandrina, Jose Santana, Ryan Schweitzer
Las Lajas	Sanchez Ramirez	Alejandrina Rosa, Nelly, Ryan Schweitzer
Ceibet de Bonet	Santiago Rodriguez	Alejandrina Rosa, Ryan Schweitzer
INOA	Santiago	Maximo, Nelly, Alejandrina Rosa, Ryan Schweitzer
Los Lirios/La Lanza	Barahona	Clara María Mosquea Jiménez, Ryan Schweitzer

A.9. Complete List of the Peace Corps Water Systems.

Note: The total cohort (118 systems) used for the research reflects the total number of RWS with community management organizations (122 systems) removing abandoned systems or those serving populations greater than 2,000 people. The sample (42 systems) selected for evaluation that participated are highlighted in yellow.

Count	Name(s) of community	Province	Population
1	Los Guanos	Azua	63
2	Las Guamas	Azua	133
3	El Memiso	Azua	173
4	El Derrumbado	Azua	180
5	La China	Azua	254
6	Arroyo Colorado	Azua	261
7	Cañada Cimarrona	Azua	300
8	Las Lagunas	Azua	500
9	El Recodo	Azua	585
10	Los Frios, Montacitos, La Cucarita, El Jengibre	Azua	6060
11*	Mundito	Barahona	80
12	Los Cercadillos	Elias Pina	198
13	Sabana de la Loma	Elias Pina	300
14	Asiento de Miguel, Lo Mesa, Las Arañas	Elias Pina	350
15	El Corbano, La Descubierta, La Palma	Elias Pina	450
16**	Angel Felix	Independencia	unknown
17	Las Bolos	Independencia	375
18	Boma	La Vega	unknown
19	Arroyo Frio	La Vega	unknown
20	Manguito	La Vega	42
21	Paso de La Perra	La Vega	80
22	Arroyo La Pita	La Vega	90
23	Arroyo de los Muertos	La Vega	104
24	Mata de Café	La Vega	105
25	Angosto	La Vega	110
26	Arroyo de Rancho	La Vega	116
27	Los Marranitos	La Vega	125
28	Arroyo Bonito	La Vega	150
29	Pino de Rayo	La Vega	158
30	Angostura	La Vega	159
31	La Joya de Ramon	La Vega	250
32	La Descubierta Arriba	La Vega	270
33	La Descubierta Abajo	La Vega	300
34	La Guamita	La Vega	350
35	El Jamito	Monte Plata	data sheet
36	Hoyo de Pum	Monte Plata	70
37	Sabana de Payabo	Monte Plata	250
38	Frias	Monte Plata	700
39	Paso de los Burros	Puerto Plata	unknown
40	El Manguito	Puerto Plata	unknown
41	Gualete Arriba, La Caoba	Puerto Plata	unknown
42	Alto de la Jagua	Puerto Plata	unknown
43	Arroyo El Toro	Puerto Plata	34
44	Arroyo Ancho	Puerto Plata	34
45	La Vereda	Puerto Plata	80
46	Alto Bohio	Puerto Plata	90
47	La Loma de Gurabo	Puerto Plata	90
48	Los Caraballos	Puerto Plata	100
49	El Cumbi/Pueblo Chico	Puerto Plata	135
50	La China	Puerto Plata	137
51	Guazaral	Puerto Plata	140
52	La Lagunita	Puerto Plata	150
53	Huevito (Escalera Abajo)	Puerto Plata	201
54	Gurabo Abajo	Puerto Plata	220
55	Los Lirios	Puerto Plata	220
56	Cruce de Pescado Bobo	Puerto Plata	230
57	El Puerto de Barrabas	Puerto Plata	300
58	Arroyo Blanco	Puerto Plata	386
59	Los Llanos/ La Jagua	Puerto Plata	649
60	Bajabonico Arriba	Puerto Plata	1000
61	El Copey	Puerto Plata	unknown
62	Baja Boniquito	Puerto Plata	unknown
63	Guaranal, Quita Sueno	Puerto Plata	data sheet
64	Palma Picada	Puerto Plata	unknown
65	Higuero	Puerto Plata	data sheet
66	Los Arroyos	Salcedo	86
67	Los Palmaritos	Salcedo	95
68	Laguna Grande	Samaná	360
69	Cumia Arriba	San Cristobal	data sheet
70	Los Toros Arriba	San Cristobal	350
71	Los Toros Abajo	San Cristobal	971
72	El Duey (Las Cuevas)	San Cristobal	unknown
73	Los Limones	San José de Ocoa	96
74*	Los Negros	San José de Ocoa	134
75	El Rifle	San José de Ocoa	200
76	La Cienaga	San José de Ocoa	212
77	La Cruz/Demajagua	San José de Ocoa	217
78	La Cienaga	San José de Ocoa	268
79*	Los Fogoncitos, La Trocha	San José de Ocoa	300
80	Los Palmaritos/Los Corozos/El Caimintal	San José de Ocoa	503
81	Los Tramojos	San José de Ocoa	800
82	Arroyo Bonito	San José de Ocoa	unknown
83	Pinal de la Cana	San Juan	116
84	Sabana Bonita	San Juan	200
85	Abra de Las Yayas, Los Tablones, Guamalito, Lagunita	San Juan	349
86	La Guazara	San Juan	409
87	La Vereda, La Hermita, Pedro Alejandro	San Juan	450
88	El Corozal, La Sierra, Los Corocitos	San Juan	614
89	Carrera Bonita La Palmita, Sabana en Medio.	San Juan	700
90	Los Campeches	San Juan	950
91	La Coraza & La Vincenta	San Juan	1000
92	Boca de Humo & La Mocha & Palmar & Pinar Grande x	San Juan	1460
93	El Pando	San Juan	215
94	Los Jobos	Sanchez Ramirez	130
95	La Lomota	Santiago	data sheet
96	La Guamita 2	Santiago	9
97	Congo Arriba	Santiago	22
98	La Guamita 1	Santiago	24
99	Los Lirios	Santiago	25
100	La Mina	Santiago	27
101	Vista Alegre	Santiago	32
102	La Cacata	Santiago	40
103	Piedra Blanca	Santiago	44
104	La Guasara	Santiago	50
105	La Cabirma Abajo	Santiago	53
106	La Playa	Santiago	60
107	La Finca/Los Ramones	Santiago	63
108	Palo Quemado 2	Santiago	90
109	Congo Medio	Santiago	92
110	El Jamo	Santiago	92
111	Honduras	Santiago	128
112	Palo Alto	Santiago	132
113	El Aguacate	Santiago	415
114	Salamanca	Santiago	437
115	El Paradero	Santiago	634
116	Villa Nueva	Santiago	700
117	La Cumbre	Santiago	1420
118	Pananao	Santiago	1500
119	El Rubio	Santiago	2250
120	Palo Quemado 1	Santiago	unknown
121	Los Rurales	Santiago	1012
122	La Sierra	Santiago	560

(grey)	Eliminated for population size > 2,000
(yellow)	samlple community (selected randomly from province)
(red)	selected for sample but did not participate.
*	Eliminated because system was abandoned or not functioning.
**	Unknown that system was disabled/abandoned

A.10. List of Communities and Survey Administrators for Peace Corps Systems (continued on next page)

Only 40 of the 42 Peace Corps systems selected were surveyed. Two systems from the original sample (Angel Felix and El Duey) were not included in the data manipulation. In both cases the communities did not participate due to logistical and communication issues. The initial sample size was calculated at 41 systems and a sample size of 40 produces an acceptable confidence interval.

Name(s) of community	Province	Survey Administrator
El Memiso	Azua	Ryan Schweitzer
Arroyo Colorado	Azua	Ryan Schweitzer
La China	Azua	Ryan Schweitzer
Sabana de la Loma	Elías Piña	Margo Mullinax, Ryan Schweitzer
Asiento de Miguel, Lo Mesa, Las Arañas	Elías Piña	Margo Mullinax, Ryan Schweitzer
Mata de Café	La Vega	Ryan Schweitzer
La Joya de Ramon	La Vega	Ryan Schweitzer
Angostura	La Vega	Ryan Schweitzer
Pino de Rayo	La Vega	Ryan Schweitzer
Paso de La Perra	La Vega	Ryan Schweitzer
El Jamito	Monte Plata	Ryan Schweitzer
Frias	Monte Plata	Meredith, Ryan Schweitzer
Los Caraballos	Puerto Plata	Matt Whitnall
La Vereda	Puerto Plata	Margo Mullinax, Ryan Schweitzer
Huevito (Escalera Abajo)	Puerto Plata	Joel, Ryan Schweitzer
Guaranal, Quita Sueno	Puerto Plata	Ryan Schweitzer
Higuero	Puerto Plata	Ryan Schweitzer
Guazaral	Puerto Plata	Margo Mullinax, Ryan Schweitzer
El Cumbi/Pueblo Chico	Puerto Plata	Ryan Schweitzer
Cruce de Pescado Bobo	Puerto Plata	Ryan Schweitzer
Bajabonico Arriba	Puerto Plata	Margo Mullinax, Ryan Schweitzer
Los Arroyos	Salcedo	Bobby Lehman, Ryan Schweitzer
Laguna Grande	Samaná	Ryan schweitzer
Cumia Arriba	San Cristobal	Alejandrina Rosa, Maximo, Ryan Schweitzer
La Cienaga	San José de Ocoa	Margo Mullinax, Ryan Schweitzer
La Cruz/Demajagua	San José de Ocoa	Margo Mullinax, Ryan Schweitzer

Name(s) of community	Province	Survey Administrator
Los Palmaritos/Los Corozos/El Caimintal	San José de Ocoa	Margo Mullinax, Ryan Schweitzer
Los Campeches	San Juan	Jay Thrash, Ryan Schweitzer
Pinal de la Cana	San Juan	Jay Thrash, Ryan Schweitzer
La Coraza & La Vincenta	San Juan	Jay Thrash, Ryan Schweitzer
Los Jobos	Sanchez Ramirez	Ryan Schweitzer
Los Lirios	Santiago	Margo Mullinax, Ryan Schweitzer
Los Rurales	Santiago	Ryan Schweitzer
Villa Nueva	Santiago	Ernesto, Ryan Schweitzer
La Lomota/Lidial	Santiago	Ryan schweitzer
El Paradero	Santiago	Ernesto, Ryan Schweitzer
El Aguacate	Santiago	Ryan schweitzer
Salamanca/El Chapeo	Santiago	Ryan schweitzer
La Cacata/La Penita	Santiago	Ryan schweitzer
Pananao	Santiago	Ryan schweitzer

A.11. "Sustainability Snapshot" Developed by WaterAid.

Financial	
1	No funds available for maintenance when needed
2	Funds available but not sufficient for the most expensive maintenance process
3	Funds available and sufficient for the most expensive maintenance process
Technical skills	
1	Technical skills not available* for maintenance when needed
2	Some technical skills for maintenance, but not for all
3	Technical skills for all maintenance processes available
	*Available in this context means available to an average community member within a reasonable time
Equipment and spare parts	
1	Not available when needed
2	Available but not for all repairs
3	Available for all repairs

Table A.11= Sustainability Snapshot developed by WaterAid rates is a participatory process by which a composite score (1-unlikely to last beyond first breakdown, 2-unlikely to last beyond first major breakdown, and 3-likely to be sustained) for service in a community or area is derived by selecting one statement (1, 2, or 3) for each category: financial, technical skills, and equipment and spare parts. (Sugden, 2003)

A.12. The National Water Supply and Sanitation Company of Nicaragua (ENACAL) developed an evaluation methodology for use in their regional operations and maintenance support unit (UNOM acronym in Spanish).

	Above Average	Acceptable	Below Average
Organization	Committee functioning with all members active	Committee functioning but incomplete	Committee not functioning
	Decisions made in previous month respected and adhered to by community	Decisions made by committee in previous month not universally agreed on nor respected	No decisions taken in previous month
	Meetings and decisions fully recorded	Committee functioning but with some need for external support	Organization impossible without external support
	Committee functions without external support		
Administration	Tariff system operable with 90% of h/h contributing	Tariff system operable but with less than 90% h/h contributing	Tariff system does not function
	Accounting ledgers balanced with monthly financial report	Accounting ledgers incomplete and reporting period is more than 1 month	Accounting ledgers incomplete and no financial report
	Income covers 100% of running and repair costs of system plus balance	Income covers 100% of running costs only	Income does not cover full running costs
Technical	Physical systems fully functional, out of service <1 day in previous month	System partially functional, out of service 1-3 days in previous month	System functions poorly, out of service >3 days in previous month
	Disinfection on regular basis	Sporadic disinfection	No disinfection
	Water supply 24 hours/day	Water supply at least 8 hours/day	Water supply < 8 hours per day.

Table A.12- Table used for evaluating community management of rural water systems in Nicaragua. Table adapted from Lockwood (2001) page 75.

A.13. **Field Observations Supporting the "Charismatic Individual Effect."**

Community	Anecdote
Cumia Arriba	Previous president died and "things changed" for the worse
El Aguacate	Plumber died and people stopped paying
Pino del Rayo	Treasurer and secretary both died and then everything "just fell apart"
La Joya de Ramon	President died and their duties were transferred to the plumber. Then the secretary died and the plumber had to do that work too
Pescado Bobo	Treasurer left and now community cannot withdraw money from the savings account
La Cienega	In 1995 the community stopped paying the tariff because the collector died
El Jaimito	President got sick and people stopped paying
Marmolejos	Lots of people have emigrated out of the community. The secretary left and took the money.

Table A.13- Evidence Supporting the "Charismatic Individual" effect in Rural Water Systems in the Dominican Republic. This concept shows that an individual or few individuals can play a large role (positive or negative) in the management of Rural Water Systems, and the absence of this individual has significant effects relative to the absence of anyone else in the management process.

A.14. Survey Data

Reference # on Survey Forms-->					1	2	4b	4a	5a	5b	6	7a	7b	8a	8b	9 Service							12	13	14a	14b
		Name(s) of co	Muni	Provinc	Wate	Syste	# Inh	# Co	meet	meet	meet	atten	atten	time	time	1	2	3	4	5	6	7	# ele	mont	statu	statu
INAP.	21	La Lanza/Los Lirios		Barahon	0	2	56	56	12	12	4	5	40			1	0	1	0	0	0	0	1	6	1	1
INAP.	4	El Yaguarizo	Bani	Peravia	0	11	168	148	12	1.5	3	63	36	1	1	0	0	0	0	0	1	0	3	1	1	1
INAP.	5	El Libonao		Hato Ma	0	8	68	27	12	12	3	83	0	1	1	0	0	1	0	0	1	0	2	24	1	1
INAP.	2	La cuchilla	Yama	Monte P	1	9	240	170	prob	0	0	0	0	na	na	1	0	0	0	1	1	0	1	na	1	0
INAP.	8	Las Lajas	Fatin	Sanchez	1	4	110	78	0	2	6	0	51	na	2	0	0	0	0	0	1	0	2	8	1	0
INAP.	10	Arroyo Lucas	El Se	El Seibo	1	2.5	72	42	prob	0	0	0	24	na	12	0	0	0	0	0	0	0	1	24	0	0
INAP.	20	Callejon y los S	San (	San Cris	1	3.5	140	140	4	3		5											2	21	1	1
INAP.	11	Las Barrenas/L	El Se	El Seibo	1	5	50	43	prob	prob	2	80	52	4	4	0	0	1	1	0	1	0	3	16	1	1
INAP.	15	Alejandro Bass	Cons	San Pec	0	3.5	178	121	3	0	0	63	0	1	30	0	0	1	1	1	1	0	1	51	0	0
INAP.	9	La Canela	-	San Crit	1	2.5	110	108	22	3	3	56	60	0.5	1	0	0	0	0	0	1	0	1	36	1	0
INAP.	12	Reparadero	El Se	El Seibo	1	3.5	44	28	0	3	3	0	79	na	3	1	0	1	1	0	0	0	1	30	1	1
INAP.	18	La Mora	Hato	Hato Ma	0	6.5	53	47	prob	12	1	33	47	2	0.2	1	0	0	0	1	0	1	1	71	1	1
INAP.	13	Marmolejos	El Se	El Seibo	1	2.5	45	39	12	2	1	67	100	1	6	0	0	0	0	0	0	0	1	33	1	0
INAP.	19	Batey 9	neyba	Indepen	0	1	267	206	20	12	4	5	100	2	2	0	0	1	0	0	0	0	1	37	1	1
INAP.	1	Aguas Negras	Pede	Pederna	0		45	25	0	1	1	0	89	na	4	1	0	0	0	0	1	0	1	21	0	0
INAP.	14	Batey 35	El Se	El Seibo	1		80	56	12	3	1	50	50	1	2	0	0	0	0	0	1	0	1	34	1	1
INAP.	16	El Gauyabo	Las M	San Jua	0	2	218	197	8	1	1	75	90	0.25	9.5	0	0	0	1	0	1	0	1	19	1	1
INAP.	6	Ceibet de Bonet		Santiago	1		168	146	12	1	2	100	60	1	11	0	0	0	0	0	1	0	1	48	1	0
INAP.	3	La Parcela/ El S	-	Monte P	1	4	144	84	2	12	2	71	32	2	2	0	0	0	0	0	0	0	1	5	1	1
INAP.	17	INOA	San J	Santiago	1	5	400	250	12	0.5	4	80	27	0.25	11	1	1	0	1	1	1	0	4	17	1	1
INAP.	7	Los Memisos	Higue	La Altag	1	3.5	500	212	8	2	1	3	7	2	2	0	0	1	1	0	1	0	1	48	1	0
PC	1	Los Jobos	Cotui	sanchez	0	2	32	26	24	12	1	5	20	0.5	1	0	0	1	0	0	0	1	24	1	0	
PC	3	La Cienaga	San J	San Jos	0	8	84	74	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	192	0	0
PC	7	La Lomota/Lidi	Nava	Santiago	0	6	86	55	12	50	3	100	30	1.5	1	0	0	1	0	0	0	0	3	40	0	0
PC	2	Los Palmaritos	San J	San Jos	0	13	64	72	6	2	2	57	40	0.25	0.5	0	0	0	0	0	0	0	6	6	1	1
PC	10	El Paradero	Jicom	Santiago	0	8	122	16	12	0	0	100	0	0.5	24	0	0	0	1	0	1	0	3	30	1	0
PC	4	La Coraza & L	El Ce	San Jua	0	11	114	28	0	0	0	0	0	0	12	0	0	0	0	1	0	0	2	72	1	0
PC	5	Frias	Don J	Monte P	0	7	189	82	0	0	0	0	0	na	na	0	0	1	1	0	0	0	3	12	1	0
PC	8	Arroyo Colorad	Esteb	Azua	0	9	63	55	0	0	0	0	0	0	72	0	0	0	1	0	1	0	1	108	0	0
PC	6	Los Arroyos	Tenar	Salcedo	0	16	7	6	0	1	1	0	8	na	28	0	0	0	0	0	0	0	4	na	1	0
PC	20	El Jamito	Yama	Monte P	0	4	34	31	0	0	0	0	0	6	6	1	0	0	1	0	1	0	1	48	1	0
PC	11	Pino de Rayo	Mana	La Vega	0	8	48	46	0	0	0	0	0	36	36	0	0	0	0	0	0	0	1	94	0	0
PC	15	Cruce de Pesc	Altam	Puerto F	0	3	60	55	12	12	2	80	25	0.25	0.25	0	0	0	1	0	1	0	1	30	0	0
PC	9	La China	Esteb	Azua	0	8	28	26	0	1	0	0	na	na	2	0	1	0	1	0	0	0	1	96	0	0
PC	16	El Aguacate	Jacag	Santiago	0	8	85	70	2	1	1	75	50	4	5	0	0	0	1	0	1	0	1		0	0
PC	23	La Cruz/Demaj	San J	San Jos	0	12	36	36	0	12	2	80	12	0	1	0	0	0	1	1	0	0	2	48	1	1
PC	25	Villa Nueva	Nava	Santiago	0	5	170	160	50	1	1	71	30	0.1	9	0	0	1	0	0	0	0	1	200	1	1
PC	13	Pinal de la Can	El Ce	San Jua	0	4	35	20	0	4	1	0	20	0	2.5	0	0	0	1	0	1	0	1	47	1	1
PC	14	El Memiso	Esteb	Azua	0	8	48	55	0	1	1	0	13	0	2	1	1	0	1	1	0	0	1	96	1	1
PC	17	Cumia Arriba	Camb	San Cris	0	5	90	28	0	0	1	0	0	21	21	0	0	1	0	0	0	0	1	64	1	0
PC	22	La Cacata/La F	Santi	Santiago	0	8	25	8	0	2	2	0	45	0	6	0	0	0	1	0	1	0	2	84	1	1
PC	28	Huevito (Escal	Altam	Puerto F	0	3	32	38	0	4	0	100	14	0	4	0	0	0	0	0	1	0	1	50	1	1
PC	18	Asiento de Mig	El Ce	Elias Pir	0	3	82	56	0	12	2	0	20	na	2	1	0	0	1	0	1	0	1	48	1	1
PC	19	Los Lirios	Altam	Santiago	0	6	44	45	0	4	4	0	27	0	6	0	0	0	0	0	0	0	4	20	1	1
PC	21	El Cumbi/Pueb	Altam	Puerto F	0	4	44	36	0	12	1	0	28	0	1	0	0	0	1	0	1	0	2	20	1	1
PC	27	Bajabonico Arr	Altam	Puerto F	0	10	210	48	5	4	3	100	160	na	na	0	0	0	0	0	1	0	3	30	1	1
PC	30	La Joya de Ra	La Ci	La Vega	0	8	69	45	0	12	3	0	40	na	1	0	0	0	0	0	0	0	1	96	1	1
PC	12	Los Caraballos	Altam	Puerto F	0	1	26	26	12	0	2	40	0	0.25	0	1	1	1	1	1	1	1	2	3	1	1
PC	24	Guazaral	Altam	Puerto F	0	7	35	25	0	12	1	0	25	0	1	0	0	0	0	0	0	0	4	34	1	1
PC	31	Paso de La Pe	La Ci	La Vega	0	8	22	22	0	12	1	0	18	na	2	1	0	0	1	0	1	0	1	96	1	1
PC	29	Mata de Café	Mana	La Vega	0	8	68	68	0	24	0	0	40	0	1	0	0	0	0	0	0	0	1	96	0	0
PC	33	Pananao	San J	Santiago	0	11	188	182	12	3	1	57	45	0.5	2	0	0	0	0	0	0	0	7	15	1	1
PC	34	Laguna Grande	Las T	Samaná	0	5	94	72	50	0	1	100	0	0.25	na	0	1	0	0	0	1	0	2	4	1	1
PC	26	Los Campeche	El Ce	San Jua	0	6	165	165	0	2	0	0	NA	NA	1	0	0	0	1	0	1	1	1	56	1	0
PC	37	Angostura	Mana	La Vega	0	9	60	42	12	2	0	100	42	1	1	0	0	0	0	0	0	0	1	96	1	1
PC	32	Sabana de la L	Santi	Santiago	0	8	174	138	0	2	2	0	45	0	6	0	0	0	1	0	1	0	2	84	1	1
PC	36	Guaranal, Quit	El Ce	Elias Pir	0	1	75	60	12	12	2	80	10	1	2	0	1	0	1	0	1	0	1	24	1	0
PC	35	La Vereda	Altam	Puerto F	0	2	160	155	12	12	4	80	35	1	1	0	0	0	1	0	1	0	1	98	1	1
PC	38	Salamanca/El	Altam	Puerto F	0	8	18	20	50	8	1	60	40	0.25	0.5	0	0	0	0	0	0	0	5	10	0	0
PC	39	Higuero	Altam	Puerto F	0	1	103	76	22	4	4	78	35	0.5	2	0	0	0	0	0	0	0	1	30	1	1
PC	40	Los Rurales	Nava	Santiago	0	12	130	120	0	24	2	100	45	0	3	0	0	0	0	0	0	0	2	24	1	1

Survey Data (continued)

15 Difficulties							16a	16b	17a	17b	18	20	22			23	24	25	26a	26b	27	28	30
1	2	3	4	5	6	7	Wate	% tha	Tarifl	Tarifl	how	who	moro	acco	recei	sanc	cut o	how	B=Ba	total ba	How	who?	last f
1	0	0	0	0	0	0	100	30	30	1	meeti	na	100	0	0	0	0	0	n	0	n	na	no
0	1	0	0	1	0	0	50	na	25	1	starte	pres	31.3	1	0	0	1	18	b	7287	2	pt	1
0	0	0	0	0	0	1	0	0	30	1	starte	pres,	78	1	0	0	0	0	b	3324	1	p	no
0	0	0	0	0	1	0	100	100	40	1	asser	t	92	1	0	0	1	0	b	12370	2	pt	no
0	0	1	0	0	0	0	60	100	40	1	major	vp an	37	1	0	0	0	0	b	8300	2	pt	3
0	0	0	0	0	0	0	500	68	100	1	inapa	plumb	5	1	1	0	0	0	c	4500	1	p	no
1	0	0	0	0	0	0	100	85	75	1	starte	cobra	75	1	0	0	1	3	bc	93382	2	pt	2
0	0	0	1	0	0	1	25	100	50	1	0, wa	tres	18.6	1	0	0	1	5	b	17045	2	pt	16
1	0	0	1	1	0	1	0	0	20	1		plumb	74	0	0	0	1	55	c	1500	1	plumb	no
1	0	0	0	0	0	0	200	100	60	1	inapa	pres,	15	1	0	40	1	2	b	400	2	pt	1
0	0	0	1	0	0	1	100	100	100	1	randc	sec p	14	1	0	200	1	9	b	4411	2	sec tr	3
1	0	0	0	0	0	1	0	0	50	1	starte	meeti	40	1	0	0	1	3	b	13338	2	pt	0.2
1	0	0	1	0	0	0	100	100	50	1	ability	sec	30	1	0	0	1	6	n	0	2	tres a	no
1	0	0	0	0	0	0	0	0	20		meeti	plumb	45	1	0	0	1	12	b	7800	2	pt	3
0	0	1	0	0	0	1	300	100	75	0	randc	t	72	0	0	0	0	0	b	75000	3	pts	no
0	0	0	1	0	0	0	100	100	50	f, 50 l	comn	pres	34	1	0	0	1	11	b	38163	2	pt	2
0	1	0	0	0	0	1	120	98	60	1	calcu	plumb	47	1	0	0	1	12	b	40200	2	pt	no
1	0	0	1	0	0	0	600	100	20	1	up to	comn	10	1	0	0	1	12	b	46000	2	pres p	11
1	0	0	0	0	0	0	50	100	50	1	inapa	plumb	3	1	0	200	1	13	b	34400	2	pt	5
1	0	0	0	1	0	0	10k, '	100	50	two le	raisec	sec	7.5	1	1	200	1	30	b	3E+05	2	pt	18
0	0	1	0	0	1	0	400	100	100	1	was 5	plumb	0	1	0	0	1	2	b	2E+05	2	pt	2
0	0	0	0	0	0	1	100	100	30	1	pcv	0	100	1	0	0	0	0	b	2000	2	pres t	no
1	1	1	1	0	0	0	100	100	0	na	na	na	100	0	0	0	0	0	n	0	0	na	na
1	0	0	0	0	0	0	0	0	40	1	propc	tres p	60	1	0	0	0	0	n	0	0	na	na
1	0	0	0	0	0	1	300	100	0	na	na	na	100	0	0	0	0	0	y	600	1	pres t	na
1	0	0	0	0	0	0	0	0	20	1	pcv s	cobra	75	1	0	0	1	na	b	3500	1	tres	na
1	1	0	0	0	0	0	0	0	5	1	year p	cobra	100	0	0	0	0	0	n	0	0	na	0
0	0	1	0	0	0	0	0	0	30	1	was 1	plumb	26	0	0	0	1	0	n	0	0	na	na
1	1	1	0	0	0	0	0	0	0	na	na	na	100	0	0	0	0	0	n	0	0	na	na
1	1	1	0	0	0	0	0	0	10	1	pcv s	na	100	0	0	0	0	0	n	0	0	na	na
1	1	1	0	0	0	0	50	100	20	1	0	n	100	0	0	0	0	0	c	4840	1	na	0
0	0	0	0	0	0	0	0	0	20	1	pcv s	na	100	0	0	0	0	0	c	1500	1	pres	na
0	0	0	0	0	0	0	300	100	20	1	pcv s	meeti	76	1	0	0	0	0	b	7600	2	pres t	na
1	0	1	0	0	0	0	0	0	5	1	na	na	100	0	0	0	0	0	n	0	0	na	na
1	0	1	0	0	0	0	300	100	10	1	pcv s	not pa	100	1	0	0	1	2	n	0	0	na	24
0	0	1	0	0	0	1	200	100	5	1	was 3	cobra	50	1	0	0	1	1	b	0	0	na	na
1	0	0	0	0	0	0	0	0	60	1	comn	secretari		1	1	100	1	250	b	2500			9
1	1	0	0	0	0	0	400	85	10	1	pcv	treasu	79	1	y	0	0	0	b	170	2	pres t	0
1	0	1	0	0	0	0	0	0	5	1	was 1	treasu	100	1	0	0	0	0	c	1300	0	na	na
1	0	1	0	0	0	0	200	100	20	1	pcv 3	opera	51	1	0	0	1	2	n	1200	0	na	na
1	0	0	0	0	0	0	250	100	20	1	pcv s	pres	16	0	0	0	1	18	c	11000	1	tres	6
1	1	0	0	0	0	1	0	0	20	1	10 wa	pres	65	1	0	0	0	0	c	5000	1	pres	na
1	0	0	0	0	0	0	500	100	10	1	pcv	treasu	100	1	0	100	1	7	b	19418	2	tres,s	3
1	0	0	0	0	0	0	540	100	10	1	pcv	treas	61	1	0	0	0	0	na	0	na	na	na
0	0	0	0	0	0	1	300	100	20	1	10 RD	cobra	11	1	y	0	1	2	c	4200	2	tres,s	0
1	0	0	1	0	0	1	0	0	25	1	was t	cobra	25	1	0	0	1	2	n	0	0	na	na
0	0	0	0	0	0	0	0	0	10	1	pcv s	pres	0	0	1	0	1	3	c	2300	1	pres	1
1	1	1	1	1	1	1	400	100	30	1	small	secre	0	1	0	0	0	0	b	4000	2	pt	3
0	1	1	0	0	0	1	500	100	5	1	small	plumb	74	1	0	0	0	0	b	4781	1	sec	1
0	0	1	1	0	0	1	0	0	10	1	5 was	tres	10	1	0	0	0	0	c	500	1	pres	na
0	0	0	0	0	0	0	0	0	5	1	pcv s	cobra	0	1	0	0	1	1	b	7000	na	na	na
0	0	0	0	0	0	1	0	0	25	1	na	meeti	5	1	1	0	1	1	b	1E+06	2	pre tr	2
1	0	0	0	0	0	0	0	0	30	1	20 at	anyor	13	1	0	0	1	40	c	6000	1	tres	15
1	0	1	0	0	0	0	0	0	10	1	5 at fi	treasu	95	1	0	0	1	0	n	0	0	na	0
0	0	0	0	0	0	0	0	0	5	1	was 1	pres,p	0	1	0	0	0	0	bc	6670	2	pres,	9
1	0	0	0	0	0	0	250	100	20	1	pcv s	pres	16	0	0	0	1	17	c	11000	1	tres	6
1	1	1	0	0	0	0	500	100	20	1	pcv	cobra	35	1	0	0	1	7	b	23000	3	pres t	13
0	0	0	0	0	0	1	500	100	30	1	evalu	meeti	0	1	1	0	1	y	b	61355	2	pres s	0.25
0	0	0	0	0	0	0	500	100	5	1	pcv s	treasu	25	1	0	0	0	0	b	12680	2	sec tr	1
0	0	0	0	0	0	0	400	100	40	1	neigh	na	1	1	1	0	0	0	b	5000	2	pres t	na
0	0	0	0	0	0	1	200	100	40	1	choos	club c	5	1	1	0	1	15	b	3000	2	pres t	3

A.15. Nonparametric Correlation Test

A nonparametric correlation test was used to evaluate the correlation between the indicator scores for each of the eight indicators and the data responses from Questions #2.8 and #2.7. The statistic used is a special case of the Pearson's Product-Moment Correlation Coefficient, called Spearman's Rho, (see Equation below). The null hypothesis of the test is that there is no correlation between the data sets (indicator scores and Q#2.7/#2.8) or that Rho is 0. At a probability of less than 5% we can reject the null hypothesis and accept that the data sets are correlated. To calculate Rho the data is ranked in order and the number rank is used for the values of X and Y.

$$\rho = \frac{n(\sum x_i y_i) - (\sum x_i)(\sum y_i)}{\sqrt{n(\sum x_i^2) - (\sum x_i)^2}\ \sqrt{n(\sum y_i^2) - (\sum y_i)^2}}.$$

H_O : $\rho = 0$ Two Distributions are not Correlated
If p value < 0.05 then reject H_O

Question #2.8	Activity Level	Participation	Governance	Willingness to Pay	Accounting	Financial Durability	Repair Service	System Function
Spearman's Rho	0.3103	-0.081138	0.227062	0.283768	0.276427	0.200123	0.06177	0.40172
Probability	0.0016	0.0478	0.0072	0.002	0.0026	0.008	0.0444	0
Question #2.7								
Spearman's Rho	-0.50	-0.18	-0.31	-0.63	-0.37	-0.54	-0.27	-0.32
Probability	0.0028	0.3524	0.1556	0.0004	0.0672	0.0062	0.5824	0.2938