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PERSPECTIVES ON ENVIRONMENTAL MANAGEMENT SYSTEM REQUIREMENTS

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Table of Contents

List of Figures

List of Tables

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And lastly, I am indebted to the town of Palpa, my own Macondo on the desert coast of Peru. A forgotten town with a rich history dating back to pre-incan times that will someday be wiped off the face of the earth by a *paracas*, the quechua term for sandstorms. But for now, they have more empowered leaders.

Acronyms

WUSC/SUMCANADA	World University Service of Canada
NGO	Non-governmental Organization
SENATI	National Technical Learning Institute
SUNASS	National Superintendent for Sanitation Services
SUNARP	National Superintendent for Public Registry
SUNAT	National Superintendent for Customs and Tax Administration
DIRESA	Regional Health Department
PRONASAR	National Rural Water and Sanitation Program
OEFA	Environmental Evaluation and Supervision Organization
EMAPICA	Public Water Company Ica-Palpa
EPS	Public Water Service Provider
OE	Specialized Operator
QCA	Qualitative Comparative Analysis
UNOPS	United Nations Office for Project Services
EMS	Environmental Management Systems

Abstract

This report offers perspectives on effective environmental management procedures gained through field experience with the Peace Corps in Peru and with the United Nations Office for Project Services (UNOPS) in Copenhagen, Denmark. The work in Peru focused on case studies of rural water supply management within the context of local legislation and development strategies and environmental management principles. The objective of this study was to lay out a framework for future development workers and governmental agencies aiming to improve the administration and operation of rural water system. UNOPS on the other hand, as the operational arm of the UN for the provision of infrastructure services, had piloted an Environmental Management System in compliance with ISO14001 standards in 2013. The work there involved identifying gaps in the system requirements and providing support to field operations in over 40 countries. The work with UNOPS was informed by the environmental management work started in Peru. The lessons learned on legal requirements and compliance and identifying the relevant supporting institutional stakeholders proved essential in supporting country offices in the implementation of the UNOPS Environmental Management System.

The first component is a literature review of work done by the Canadian governmental organization World University Service of Canada (WUSC) in Ancash, Peru. The outcomes of this intervention were published in a Peruvian Water and Sanitation periodical. This case study was selected because this same organization, in the years 1990-1995, worked on developing rural water access in the province of Palpa, another region of Peru and the site of volunteer service with the Peace Corps from 2010-2014. This field research allowed for an

ethnographic study of the region 20 years after the initial scope of the intervention highlighting lessons learned and making recommendations for improvements. This study looks at ten rural water supply systems using Qualitative Comparative Analysis methods to identify causal relationships between the organizational management of these communities. Having identified the key activities required for the effective management of rural water supplies and the relevant stakeholders, it was possible to present the local government with a Rural Water Security Plan, outlining the course of action for improved water services. The organizational framework for the administration, operation, and maintenance of these water systems is then broken down according to Engineering Project Organization principles, taking into account the peculiarities of intermittent water supply management in order to determine the most sustainable course of action for improving rural water system management.

Finally, a summary is provided of the work accomplished with the Sustainable Infrastructure Practice Group of UNOPS, under the Health, Safety, and Environmental Management Program. Working within the structure of the ISO standards, the focus is on a risk based approach to project planning and emergency preparedness with attention to detail regarding the maintenance of records, legal compliance, and the monitoring of program performance.

1. Introduction

Overview

Through the initial community diagnostic phase of volunteer service with the US Peace Corps in the province of Palpa in the region of Ica, Peru, the need for improving water access and quality became a priority. This study is meant to serve as a guide to governments, NGOs, and the Peace Corps Water and Sanitation program and to provide a clear plan of action for infrastructure management scenarios in both rural and urban/ private and public situations.

Previous interventions in the region by a Canadian governmental organization in the mid to late 1990s were able to implement a moderately successful community managed water system with the corresponding infrastructure. While some of this training remains, the larger part of it has been lost over time due to staff turnover rates, lack of human/technical and financial resources, and behavior changes in the community. As a result, most of the infrastructure has collapsed long before serving its intended design life. This study hopes to look at that initial intervention, see what aspects of it where successful, and at the same time develop a more sustainable, permanent solution to the water access and security needs of the communities working within the context of the existing legal framework and governmental development strategies. The proposed water security plan established a support network of entities. These key stakeholders would aid and regulate the use, treatment, and quality of water distribution and support the respective public and private organizations in providing a better service. This would be achieved through the coordination of a management system process that adheres to the strictures of Engineering Project Organization principles.

Setting

Peru

Peru is a constitutional republic in South America, which shares its borders with Ecuador, Colombia, Brazil, and Bolivia, with a wide coastal expanse on the Pacific Ocean. It is rich in biodiversity due to its diverse climatic regions of coastal desert, Andean mountains and plateaus, and Amazon rainforest. It rates high on the Human Development Index thanks to a rich industry of exploitation of natural resources such as petroleum, copper and gold mining, and logging, as well as a strong tourism industry, (Bank, 2013).

Peru has an estimated population of 30.38 million with about 70% of that living in urban settings, (Bank, 2013). As with most developing countries, income inequality is a prevalent issue with the majority of the wealth concentrated in the urban centers. The populations living in the more remote, rural locations are far removed from the laws and industry that so benefit the urban centers. While the government has many development programs, incentives, and financing opportunities, they rarely reach the more geographically isolated areas due to lack of trained professionals capable of planning and implementing development projects, (CIA, 2012).

Palpa, Ica, Peru

Palpa is the smallest of the five provinces in the region of Ica, just south of the region of Lima. According to the 2009 National Statistics Bureau (INEI) Report it has a population size of about 7,250 inhabitants. It is made up of five districts: Palpa, Rio Grande, Llipata, Santa Cruz, and Tibillo. The breakdown of the population is given in Table 3.

Figure 1: Location of the Province of Palpa, Peru (adapted from INEI, 2009)

Table 1: Population of the Province of Palpa, Ica, Peru (INEI, 2009)

Name of Town	Classification	Households	Population
PALPA	URBAN	1491	4394
SACRAMENTO	RURAL	562	1678
SAN CRISTOBAL DE CARAPO	RURAL	47	162
SAN IGNACIO	RURAL	70	274
RIO GRANDE	RURAL	1088	2731
LLIPATA	RURAL	488	1488
SANTA CRUZ	RURAL	514	1024
TIBILLO	RURAL	271	364

According to the Peruvian government, populations of 2000 or below are classified as rural. Further, according to the 2009 census the indicators that defined living conditions in the area are depicted in Table 4.

Table 2: Social Indicators Province Palpa (INEI, 2009)

Total Individual households	2593	
Households connected to Water System	1660	64%
Households connected to sewer system	1733	67%
Households with electricity	1545	60%

This suggests that 36% of the population is not on the grid for the potable water system service, with 33% lacking sewer connections or basic hygiene services.

The economy of the province is based primarily on agriculture and informal mining operations with a minimal tourism industry. It is worth noting that while the water consumption for industrial use is not currently quantified or monitored, it is significant competition for the distribution of water resources. The urban settlement is found in the midst of an archeologically rich area, ripe with overlapping remains of previous settlements from the historical Paracas, Nazca, and Wari eras, which limits zoning for new construction.

According to the records kept by the Hospital of Palpa in 2012, there were 345 incidents of diarrheal diseases. The statistics are given in Table 5.

Table 3: Reported Incidents of Diarrheal Disease in Palpa 2012

Illness	**Total**
Gastroenteritis and Colitus	228 incidents
Intestinal/Bacterial Infections	111 incidents

Food Poisoning	6 incidents
Total	**345 incidents**

Diarrheal diseases are indicators of poor water quality and hygiene practices. Diarrhea is a symptom of infections in the intestinal tract, as defined by the World Health Organization, (WHO, 2013).

Through Peace Corps service in this region, the author was able to work to focus on addressing some of these issues by working with the local government representatives to create the institutional framework for provincial environmental management. This study provides a focus on the rural water and sanitation management aspects of this intervention.

Peace Corps Peru Water and Sanitation Program

The Peace Corps is a US governmental organization created in 1962 by President John F. Kennedy to promote world peace and international development. The Peace Corps has three goals of providing technical assistance to developing communities and promoting a two-way cultural exchange for a better understanding of other cultures by Americans and of the United States by other cultures.

The Peace Corps has been in Peru since 1962. It left in 1975 due to political unrest and only returned in 2002 when invited by then President Alejandro Toledo. Currently about 170 volunteers are serving in Peru in five different programs: Small Business Development, Youth Development, Environmental Management, Water and Sanitation and Community Health Management, (PC, 2012).

The Water and Sanitation Program in Peru has three goals:

1. Low income families will improve access to safe water.

2. Low income families will improve access to sanitation and will regularly practice improved hygiene and sanitation practices.

3. Rural water committees and municipalities will better manage water and sanitation services, (PC, 2012).

United Nations Office for Project Services (UNOPS)

UNOPS is the operating agency of the United Nations; this means that they are responsible for the implementation and technical and advisory services on behalf of other UN agencies and foreign governments focusing on large- scale infrastructure, procurement, and project management services. The organization is currently certified in ISO9001 for Quality Management in all its processes, with a pilot program for all infrastructure implementation projects in ISO 14001 for Environmental Management Systems and OHSAS18001 certification for Health and Safety Management Systems, (UNOPS, 2015). The author provided support

in developing and implementing these Health, Safety, and Environmental (HSE) management systems in participating country offices.

Objective

This study will build on the factors for sustainability established by (Kaminsky and Javernick-Will, 2013) for the construction and management of household sanitation systems, as they apply to rural community-managed water systems in Peru. They used a Delphi panel of qualified experts to determine and prioritize factors of sustainability taken from extensive literature review. The 36 factors are subdivided into 6 categories: economic, organizational, knowledge, motivation, technology, and an “others” category for all miscellaneous but relevant factors. These factors were then rated as most important and least important by the experts on the Delphi panel in order to determine the overlap of opinions on the factors that contribute to sustainability.

This study will build on the *infrastructure development and governance* path of inquiry as defined by the Engineering Project Organization Journal (Chinowsky, 2011) to reinforce the socio-political structure that is necessary for the sustainability of water and sanitation infrastructure projects in the province of Palpa, with special attention to the potable water situation as outlined above. This path of inquiry implies that the sustainability of a project can only be guaranteed by the foundation in four domains or *pillars*: engineering, public policy, business, and social science. It also provides for the *horizontal life-cycle context* that looks at the various project phases as outlined by traditional project management discipline, as well as the *vertical-level perspective* which also takes into consideration the bureaucratic constraints of any given project. And finally, this path of inquiry looks at the *project governance* component of any given project that allows for a formalized interaction between the various public/private entities involved in the sustainability of the outcomes.

Previously, training efforts in the Community Management (CM) model has failed due to lack of turnover of information. This means that in order to make this a sustainable solution, a network of pertinent organizations that can provide continued technical support in the various functions of the water committees is necessary. Therefore, once municipal and other organizational networks are established, a baseline diagnostic will be conducted. This initial diagnostic using qualitative inquiries will make all parties aware of the current reality and needs of the communities. The project goals will be redefined according to these results and the capacities and competencies of the respective involved.

The objective of this project is to create the processes for a sustainable solution to the potable water service and quality in the province of Palpa using the resources available in Peru. As outlined above, the Peruvian government currently has a legal framework and initiatives that would create a sustainable solution for the potable access situation in the area, but lacks the institutional support in rural settings that already have the physical infrastructure for water services.

This paper will build on relevant literature and use ethnographic methods to determine existing conditions in Peru. Information on the development of these systems was gathered through researching project archives, informal emails with project stakeholders, and a baseline diagnostic of the rural water committee management model in the province.

This initial diagnostic looks for metrics regarding water quality and water service, including establishing existing organizational hierarchy and determining the needs of the water committees. This will lead to a monitoring and evaluation plan to be carried out continually by the various stakeholders responsible for the various aspects of providing quality service and quality drinking water. This information is then dissected for causal relationships using logical methods of Qualitative Comparative Analysis as outlined by Ragin (1987).

2. Background

The research process in this investigation created the foundation for the design of interventions in the field for the implementation of improved institutional frameworks for environmental management. In order to establish the methodology for intervention it was first necessary to establish a broad definition of sustainability in the engineering field, then to understand the implications in the environmental sector, and finally to identify the key factors of sustainability as they apply to the success of water and sanitation services and physical infrastructure. Definitions of sustainability, engineering project organization principles, and environmental management systems requirements were woven together to create a more cohesive model for the sustainability of engineering projects.

Sustainable Development in Rural Water and Sanitation

The most widely accepted definition of sustainability is that compiled by the Brundtland Commission as, “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs,” (Commission, 1987). This implies the aforementioned environmental and economic stability with an underlying theme of social equity. Efforts in sustainability have thus far focused primarily on the design and construction phases of projects, with little to no consideration to the long-term context, (Raymond E. Levitt, 2007).

Academia and industry have made tremendous efforts in creating the tools to measure the amount of energy and materials consumed and emission produced in project phases through life-cycle analysis (LCA), thus allowing organizations to cut down their ecological footprint. LCAs reflect a cradle-to-grave philosophy that is fast moving in the direction of a cradle-to-cradle, closed loop, or “add an s to loop” with the incorporation of material reuse and reduction of waste-streams as

demonstrated in Fig. 1 (SWEL, 2015). However it is worth noting that in LCAs it is the operation and maintenance phase of infrastructure projects that accounts for the greatest emissions and costs.(Guggemos, 2013)

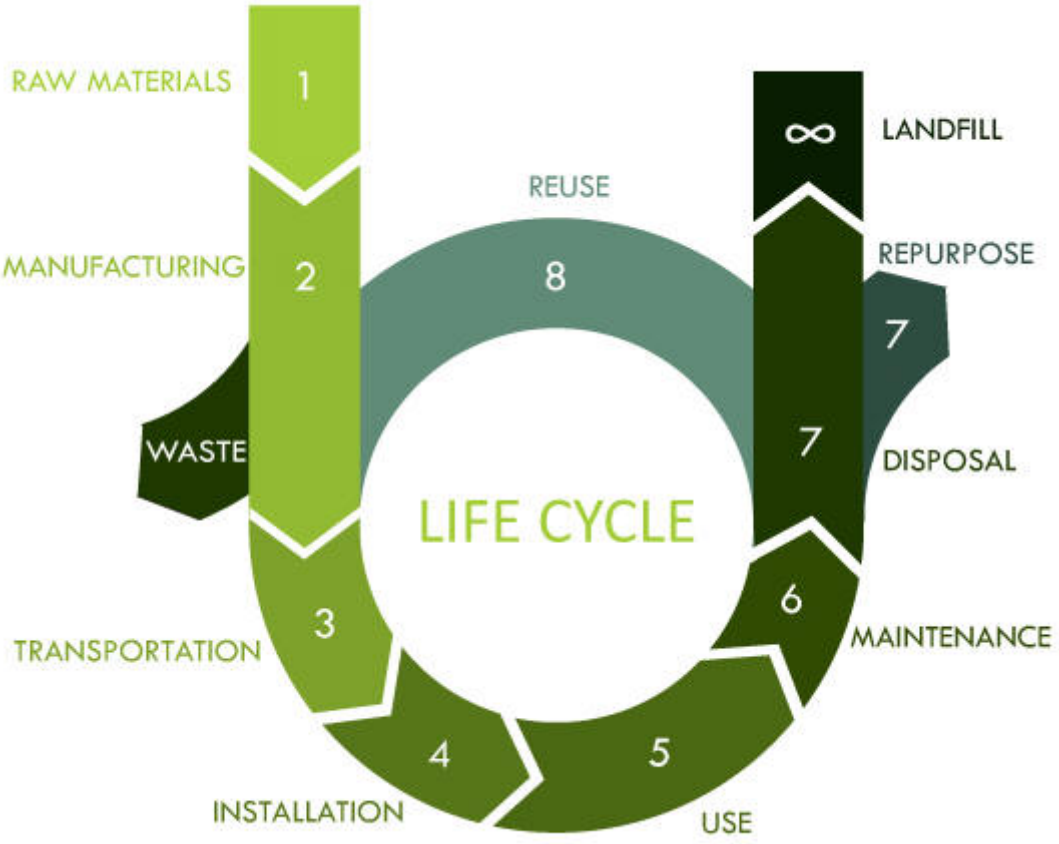

Figure 2: Life Cycle Loop (Adapted from SWEL 2015)

Rural water and sanitation work has mainly directed its efforts towards a focus infrastructure project execution focus, using participatory models to engage the local communities and build a sense of ownership, thus establishing a willingness to pay for the service. These participatory models train local members of the community in the administrative and technical needs of infrastructure maintenance, helping to establish rates and formalize a managerial model. However, the requirement for external support in creating robust management systems is well known. With the creation of the United Nations and the formalization of international development efforts, the World Health Organization

published guidelines on the best way to carry out projects of this nature (WHO, 2014), with the final stages including the creation of water system administration with support from a governmental agency from the health or public works sector, with the technical and managerial experience lacking in rural communities, where "competence in management can only be gained through experience in it," (Lanoix, 1959). WHO encourages the involvement of the public health administration, with a direct investment in water quality control, as key stakeholders in the institutional support network for these rural water systems.

According to the UN 2030 Agenda for Sustainable Development, Goal 6 aims specifically to, "ensure the availability and sustainable management of water and sanitation for all." This encompasses everything from improved water resource management to supporting local communities in improving water and sanitation management practices, (UN, 2015). According to the UN Water and WHO collaboration in a report on increasing access to water and sanitation practices, most developing countries, while recognizing the importance of water and sanitation access, lack the human and/or financial resources to follow through on the programmatic planning, implementation, and monitoring of targets in this field, (WHO, 2014).

Factors of Sustainability

Kaminsky and Javernick-Will (2013) distinguishing between hardware (infrastructure, technology, etc) and software (knowledge, institutions, education, etc), postulated that an improved definition of the software requirements would lend itself to improved sustainability of the related hardware in the engineering and construction discipline. Kaminsky and Javernick-Will were able to identify, through extensive literature review, 40 factors that contribute to sustainability of on-site wastewater treatment systems. These 40 factors were subdivided into 6 categories; Economic, Organizational, Knowledge, Motivation, Technology, and Other, (Kaminsky and Javernick-Will, 2013).

These factors were then submitted for ranking on a Likert scale from most important to least important by using the Delphi panel method where a team of experts was asked to weigh in. This study is especially relevant in this situation because it addresses the needs of rural systems, such as those that will be analyzed in this paper. The categories and factors are depicted in Fig. 2.

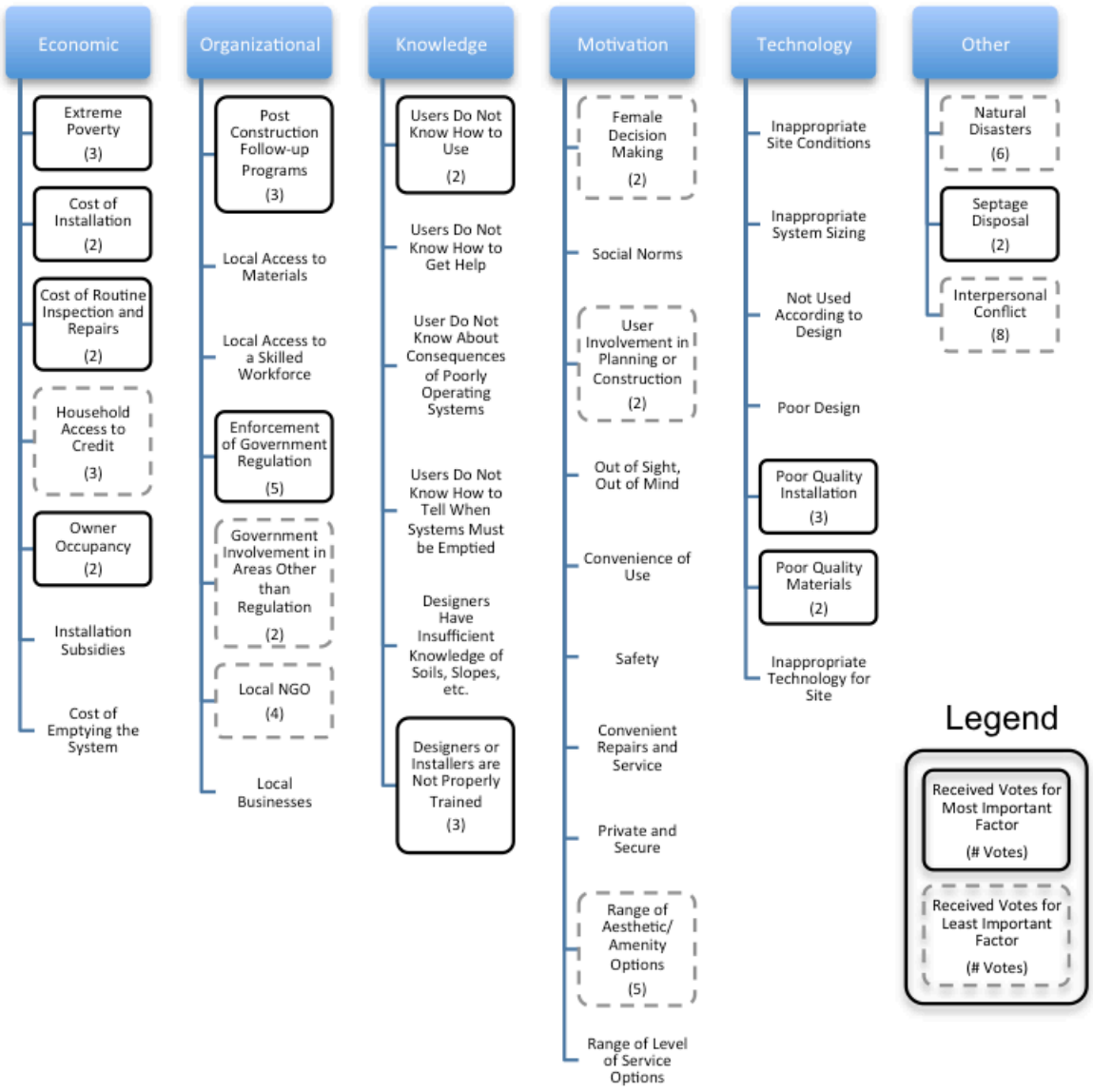

Figure 3: Most/Least Important Factors Map (Adapted from Kaminsky and Javernick-Will, 2013)

Kaminsky and Javernick-Will analyze the data, and the individual comments and responses of the diverse panel of experts, highlighting interesting tendencies and outliers, concluding that, “system software is more likely to be the root cause of

system failure than the hardware itself," (Kaminsky and Javernick-Will, pg 23). Due to these conclusions, this project's focus will remain largely on increasing the "enforcement of government regulations", considered the most highly rated factor in terms of importance for the sustainability of systems, and "post construction follow-up programs" to address the operation, maintenance and water treatment needs of the rural water systems.

Water Governance

Governance is defined by the Institute of Governance as "the process by which stakeholders articulate their interests, their input is absorbed, decisions are taken and implemented, and decision-makers are held accountable," (IOG, 1990). Historically there are three different types of public utilities governance models, which basically differ in the routes of accountability; these are planning, market, and community model. Water systems are often subject to transitions or hybrids between these as the local politics or the needs of the community evolve. In these governance models the planning model is subject to direct governmental management, while in the market model it is a private corporation, and in the community model the users are directly responsible and tend to own the related infrastructure as well, (Nazif, 2010).

Previous works by Peace Corps Master's International (PCMI) students in the Michigan Tech program include components of water governance. Worth highlighting are the results of Brandon Braithewaite, Ryu Suzuki, and Erica Jones in Panama. Braithewaite developed and implemented a training seminar for water committees created by Peace Corps volunteers in Bocas del Toro, Panama. The sessions included topics on water treatment, system operations and maintenance, legalization, accounting, and watershed management, (Braithewaite, 2009). These topics are included in the proposed Provincial Rural Water Security Plan for the province of Palpa, Peru. Suzuki performed a monitoring and evaluation of rural water systems built by previous volunteers in the Environmental Health program of Peace Corps Panama and a non-

governmental organization, Waterlines. Suzuki used a scoring system with ten indicators including technical system requirements (i.e. watershed, source capture, storage tank, distribution system, system reliability, etc.) and organizational constrains (i.e. active water committees, maintenance, accounting and transparency) to assess 28 communities, (Suzuki, 2010). Suzuki recommended a circuit rider model, a shared operations and maintenance technician to provide post-construction support and training to the participating water committees. This proposed Circuit Rider model, based on one implemented by the United States Department of Agriculture (USDA), was then implemented by Erica Jones, who acted as the Circuit Rider technician during 2012-2013, while working on improvements to renovate two spring captures for an existing gravity-fed water distribution system in the community of Ceni Pita. According to Jones, historically the Peace Corps Circuit Riders have minimal interaction with Panamanian agencies and recommends that the institutional support network should be established, (Jones, 2014). These findings are relevant to the study in that the assigned local counterpart in Peru, the local health ministry representative responsible for water quality monitoring currently acts as a circuit rider for the Palpa province, providing ad hoc technical support, recommendations, and empowerment to the rural water committees.

Intermittent Water Supply

A common misconception is that intermittent water supply is due to lack of available water resources, when in fact, with the proper infrastructure and management of water demand, continuous service is often possible. Intermittent supply usually occurs when the infrastructure is taxed beyond its hydraulic capabilities. This is a result of inadequate governance practices and the lack of proper conflict management venues for taking to task inappropriate use of drinking water supply when used for watering gardens or hosing down the sandy roads for dust control, to name a few examples. According to the literature, less than 24 hours of continuous water service is unacceptable due to the implied

health risks, although proper hygiene, storage, point-of-use treatment, and education can counteract some of these issues in the interim of water system rehabilitation, (McIntosh, 2003).

Engineering Project Organization

The Engineering Project Organization (EPO) Journal, in the article “Defining a Line of Inquiry and Path Forward,” by Paul Chinowsky, proposes a management framework that takes into consideration the more global context in which a project is meant to succeed, including the long-term vision of its role in society, meaning that the success of a project extends beyond standard project phases. Chinowsky (2011) lays out the standard project phases along a horizontal life-cycle continuum, and the societal impacts along a vertical-level context, including governmental regulations and organizations that ultimately serve society. These are grounded on the “pillars,” or fields of contribution to improved engineering project management practices; these being engineering, social science, business, and public policy. Project governance, or the formalized context and interactions that lead to successful implementation, coalesces the above-mentioned disciplines. This principle can be seen in Fig. 3 reprinted from the Engineering Project Organization Journal, (Chinowsky, 2011).

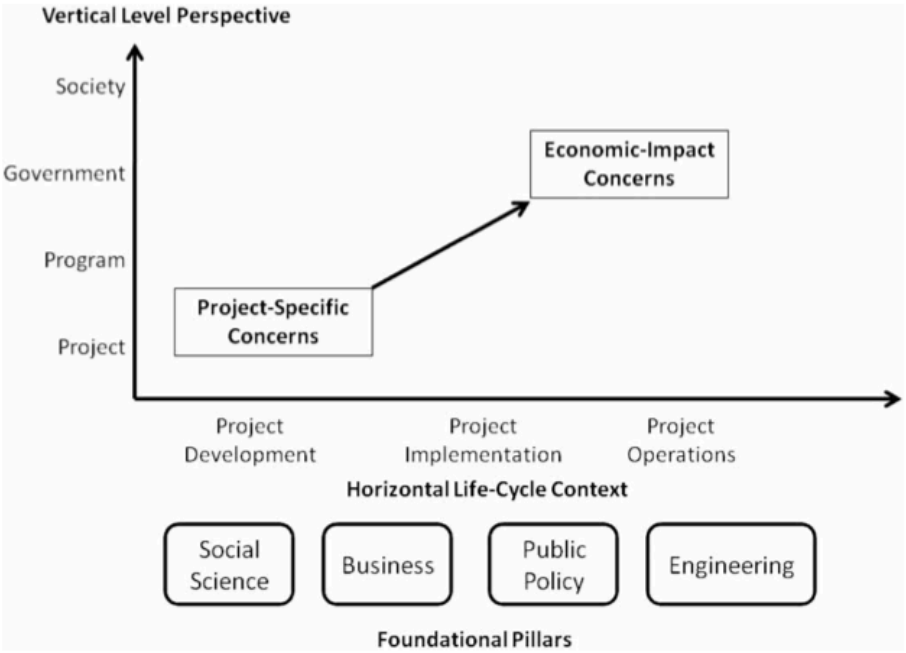

Figure 4: Definition of Engineering Project Organization (Adapted from Chinowsky, 2011)

The management framework of engineering project organization can be updated to include environmental concerns as a foundational pillar, providing a model that takes into consideration the three tiers of sustainability: social equity, environmental and economic sustainability, (Commission, 1987).

Environmental Management Systems (EMS)

The International Organization for Standardization uses the Plan-Do-Check-Act (PDCA) methodology for establishing a framework for organizational management processes for continuous improvement. The purpose of an EMS is to increase compliance and reduce environmental impact by establishing policies, implementation procedures, and monitoring practices that place emphasis on identifying legal and training requirements and the monitoring and evaluation of performance, (ISO, 2004). This is relevant to the study at hand in that achieving sustainability of the organizational framework requires focus on

these key aspects by reinforcing the institutional capacities to perform the PDCA cycle.

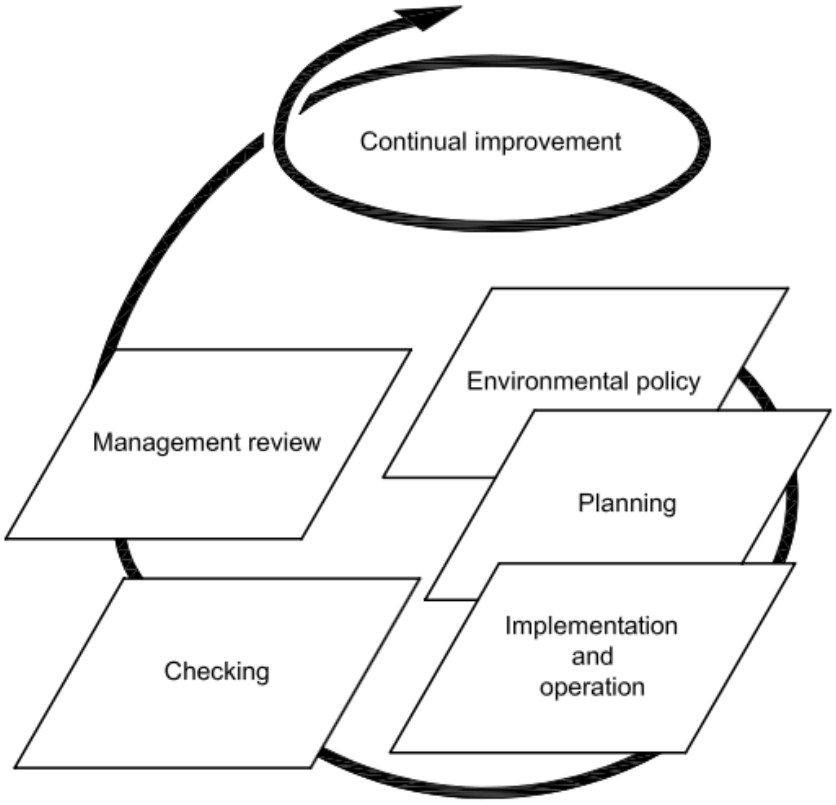

Figure 5 Cycle of Continuous Improvement (Adapted from ISO 14001, 2004)

The requirements for ISO14001 standards on environmental management systems are summarized in the following table.

Table 4: Summary ISO 14001 Requirements

Item	System Requirements	Summary
4.1	*General Requirements*	Defines breadth and scope of EMS
4.2	*Environmental Policy*	Outlines required content of organizational environmental policies and procedures

4.3	*Planning*	
4.3.1	Environmental Aspects/Impacts	Hazard identification and Impact assessments
4.3.2	Legal Requirements	Identify relevant legislation as it applies to key environmental aspects
4.3.3	Objectives, Targets, Program	Defines measurable objectives and targets and establishes a timeframe for results
4.4	*Implementation and Awareness*	
4.4.1	Resources, Roles, Responsibility	Clear representation of reporting hierarchy and responsibilities for EMS
4.4.2	Competence, Training and Awareness	Provide relevant trainings and maintain records
4.4.3	Communication	Managing internal/external communications, promotional/educational campaigns, and complaints
4.4.4	Documentation	Scope of records to be maintained to effectively demonstrate proper implementation of EMS
4.4.5	Control of Documents	Ensure information is up to date, easy to access, and approved for distribution
4.4.6	Operational Control	Establishes procedures for routine hazard control
4.4.7	Emergency Preparedness and Response	Establishes procedures for emergency response
4.5	*Checking*	
4.5.1	Monitoring and Measuring	Establish procedures to monitor performance of relevant activities
4.5.2	Evaluation of Compliance	Check for legal compliance and other requirements (ie international standards)
4.5.3	Nonconformity, Corrective Action, and Preventative	Identify and correct nonconformities for continuous improvement

	Action	
4.5.4	Control of Records	Establish procedures for archiving and retrieving relevant information
4.5.5	Internal Audit	Establishes requirements for internal audits and reviews of processes
4.6	Management Review	Top management reviews performance and defines recommendations for improvement

3. Methodology and Framework

Research Context

The graduate-level work discussed here included two opportunities for field research and international exposure, the first as a volunteer with the Peace Corps in Peru for two and a half years and the second as a Health, Safety, and Environmental Management intern with the United Nations Office for Project Services (UNOPS) based out of their headquarters in Copenhagen, Denmark.

The fieldwork in Peru entailed a process of gradual discovery in which a volunteer is required to perform an initial needs assessment of the assigned community in order to determine the scope of intervention where the overlap of needs met the program goals and requirements. The first three months are allotted for getting to know the community, assigned to a professional counterpart that will make the necessary introductions to the relevant institutions. In the province of Palpa, the identified counterpart was a representative of the local water quality inspector from the regional health ministry. He provided introductions to the local water committees and health posts, inspections and testing of the water systems, and background anecdotal information on the changes in the systems in the thirteen years he worked in the area.

Having completed the initial needs assessment and identification of key stakeholders, it was apparent that the success of rural water and sanitation services depended on the formalization of external technical and administrative

support for the responsible informal, autonomous water committees. This required combing through legislation to identify the governmental agencies legally mandated to provide support in any capacity to these communities. The identification and formulation of a stakeholder map then allowed for extensive lobbying of these governmental agencies on a local, regional, and federal level, placing the problem of rural water and sanitation on their list of priorities. Lobbying involved creating a system of checks and balances where the goodwill of some agencies helped negotiate the involvement of more reluctant parties.

A turning point in lobbying efforts came when the provincial municipality accepted their responsibility by designating a division for provincial environmental management. This office worked to create Provincial Solid Waste Management and Water Security Plans. The latter involved an initial needs assessment that simultaneously formalized the initial diagnostic and created a directory of rural water committees in the province. This diagnostic informed the Water Security Plan, which outlines the framework for improving rural water access.

Concurrently with lobbying efforts, it was possible to gain more information about the physical infrastructure by conducting interviews with the original engineers who worked with the Canadian WUSC to build some of the older systems. The engineers were identified by the documentation left in the hands of the committees, including original blueprints and assembly meeting minutes for the original community engagement in the project planning phases.

Methodology

The fieldwork entailed in this case study required delving into the communities and gaining insight, firsthand using ethnographic methods for gathering qualitative data. Ethnographic studies use a systematic method of observing the culture, or social environment through observation. This model validates these observations by having more than one type of scenario that corroborates a fact. This can be achieved through direct observation, interviews, team discussions, documents, etc. While this method has been of increased use in the field of

Construction Management, those studies that did not consult with social scientists lack in proper methodological execution. (Andreas F. Phelps, 2010)

Data Collection

Initial interviews were conducted during the needs assessment phase. The first interview conducted was with the local counterpart, officially assigned by the Peace Corps, a representative of the regional health ministry who is responsible for provincial water quality monitoring. Because of the nature of his work, and his background as a chemical engineer, he was familiar with all of the water systems in the area and their strengths and weaknesses in terms of resources and leadership. Every introduction to the currently serving voluntary committees was preceded by a brief history of the physical infrastructure and local politics.

The water committees were forthcoming with their history and challenges in the provision of adequate services. They permitted access to their historical archives. It was possible to identify leaders in the communities, who shared recollections about the community engagement efforts preceding the construction of the water systems some 20 years ago.

Following personal communications with the now retired Canadian Project Manager, it was feasible to track down the sociologist and engineer who worked with WUSC, both Peruvian nationals based in Lima. The engineer provided anecdotes about the donkey-powered wells and outlined how it was possible to identify candidates for the position of technical operator within each community. He stressed the intrinsic knowledge of the infrastructure provided by the community's contribution in kind for labor in the construction process. The sociologist provided insight into the key behavior change components of the project which included the promotion of latrine use, hand washing, and the corralling of small animals (chickens, guinea pigs, goats) which formerly roamed free in the household kitchens; a practice that has not been completely eradicated in the region.

Finally, during the process of researching local institutions it was helpful to establish a point of contact within each to better define the perceived roles, responsibilities, and jurisdiction of each institution, and later on to follow up on their legal mandates.

Table 5: Participants in Formal/Informal Interviews

Position	**Institution**	**Gender**	**Date of Interview**
Provincial Water Monitoring Technician	Regional Health Ministry (DIRESA)	M	2010-2014*
Regional Director	Regional Health Ministry (DIRESA)	M	2011-2014*
Provincial Director Water Authority	National Water Authority (ANA/ALA)	M	2011-2014*
Engineer	National Rural Sanitation Program (PNSR/PRONASAR)	M	2012-2014*
Director	Regional Environmental Ministry (MINSA)	M	2012-2014*
Regional Director	OEFA	M	2012-2014*
Local Representative	SUNARP	F	2012-2014*
Provincial Mayor Palpa	Provincial Municipality	M	2010-2014*
Provincial Environmental Management Representative	Provincial Municipality	M	2010-2014*
Former Director	World University Service Canada (WUSC)	M	June 8, 2012
Former Engineer	World University Service Canada (WUSC)	M	July 2, 2012
Former Sociologist	World University Service Canada (WUSC)	F	July 2, 2012
President Vizcas- Carlos Tijeros	Water Committee	F	2010-2014*
President Santa Cruz	Water Committee	M	2010-2014*
President Rio Grande	Water Committee	M	2010-2014*

* Provided ongoing discussions and support.

President Ingenio	Water Committee	F	2010-2014*

Lacking the sociological background, there was no formal coding of these interviews, but review of field notes shaped a timeline of events for the interventions and progress of these water systems and communities. With the exception of the three representatives from WUSC, the other participants maintained an ongoing informal dialogue, for which reason no dates of interview can be provided. An estimated period of communication has been provided, where local representatives of water committees were introduced early in the Peace Corps service, regional and national institutional representatives contacts with the exception of the Health Ministry were established and maintained as of a year in to service. It is also worth noting that the water and sanitation sector, with the exception of a number of female water committee presidents, is a male-dominated field. Only four water committee presidents are listed because they provided ongoing support, and were initially introduced to the author by the health ministry representative and local counterpart, as the most forthcoming in creating context for the historical background and current realities of provincial rural water and sanitation conditions.

The majority of the water committees were provided with as-built blueprints of the water systems. During the diagnostic phase for the water security plan, one of the measures of success for a system was proper documentation of financial accounts, meeting minutes, yearly work plan, and yearly budgets.

A key aspect of developing a stakeholder map of supporting institutions included the analysis of the legal mandates of each of these, in order to determine their jurisdiction and responsibilities.

Throughout the process of initial needs assessment, identifying the problem, researching institutions, formal and informal interviews, and presentations and conferences various journals and photographs were used to take personal notes and record anecdotes. This allows for a more complete, detailed account of acquired information and observations. This facilitated the process of discovery

and engaging with local communities and institutions in that these journals and photographs were easily accessible for cross-referencing in preparations or during interviews, in preparing presentations for authorities, providing the background for sustaining inferences and conclusions. A summary of these field notes is included under the section of this report detailing the current situation of infrastructure and management of rural water supplies in Palpa, Peru.

Framework

In the review of these case studies of rural water system management in Peru, within the context of the findings of Kaminsky and Javernick-Will's factors for sustainability, it is possible to identify an intervention strategy for improving rural water and sanitation access within Peruvian government regulations and development strategies. It is possible to look at previous work and lessons learned by the Canadian organization WUSC in the region of Ancash in creating an institutional support network for rural water committees. In the district of San Marcos in Ancash, WUSC was able to successfully intervene on an organizational level to improve the operations and maintenance of these community-operated systems. This case study served as a model for the diagnostic and initial interventions in the Province of Palpa, where the Peace Corps service and field research were carried out between November 2011 through January 2014. The results of the initial fact-finding and diagnostic in Palpa are discussed within the EPO framework, with a major focus on the vertical-level perspective of organizational requirements, which were identified as the focus for the intervention strategy; and a glance at the horizontal-level perspective of physical infrastructure, which having established the technical capacity in the field for building water distribution infrastructure, was addressed in less detail. The findings from the diagnostic are analyzed using Qualitative Comparative Analysis methods. Recommendations are presented within the

ISO14001 Environmental Management Framework of the Plan-Do-Check-Act cycle.

Engineering Project Organization

The data will be presented and analyzed through an engineering project organization framework of the vertical-level social dimensions of water system management, along with the horizontal life-cycle project development phases, with an overall focus on existing project and program governance framework as shown in Fig. 5. The data is presented with the horizontal life-cycle context first because that is how the challenges were originally contextualized.

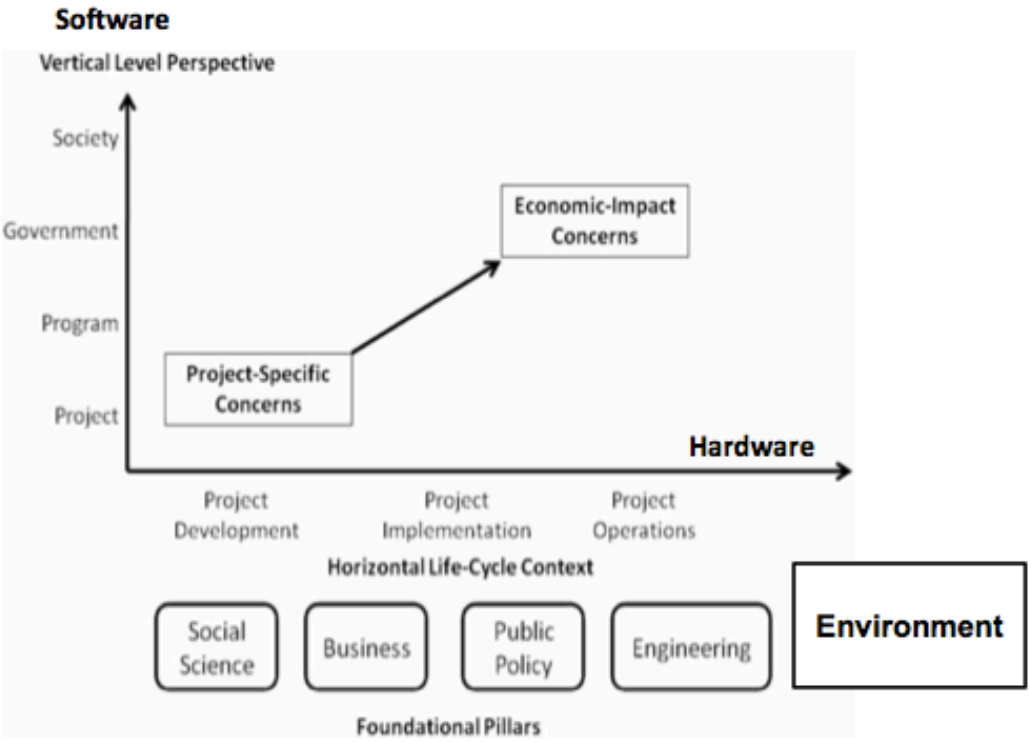

Figure 6: Framework for Analysis (Adapted from Chinowsky, 2013)

Qualitative Comparative Analysis

The administration and organizational aspects of the various systems will be analyzed using crisp-set binary (0, 1) qualitative comparative analysis methodology suitable for visualizing the presence or lack thereof of key constraints. Charles Ragin in “The Comparative Method” of 1987 first described

this analysis method using logic to make causal inferences with a small sample size. (Marshall, 1998) This method of analysis relies on a logical instead of statistical representation of the data. This method would not account for any errors or gaps in the data collected, for which reason it is complimented by the ethnographic, immersive experience of the case studies. The personal observations of the communities in question address the gaps where binary representation in a truth table, or matrix, depicting the presence or lack thereof of specific services and amenities and have been recorded in later chapters. In this method one first identifies the desired outcomes and subdivide your cases into positive and negative, then establish causal (Boolean) conditions that explain the observed phenomena, (Ragin, 2008). The use of these principles is justified given the dichotomous nature of the data on smaller-scale and larger scale rural systems.

Environmental Management System and Processes

The intervention proposed in the water security plan includes a stakeholder map of relevant institutions for establishing the plan-do-check-act cycle as depicted in Fig. 7 of environmental management systems and processes as recommended by international standard ISO 14001. These various stakeholders on a local bottom-up community level and top-down governmental level interact to guarantee the continuous improvement of rural water and sanitation management.

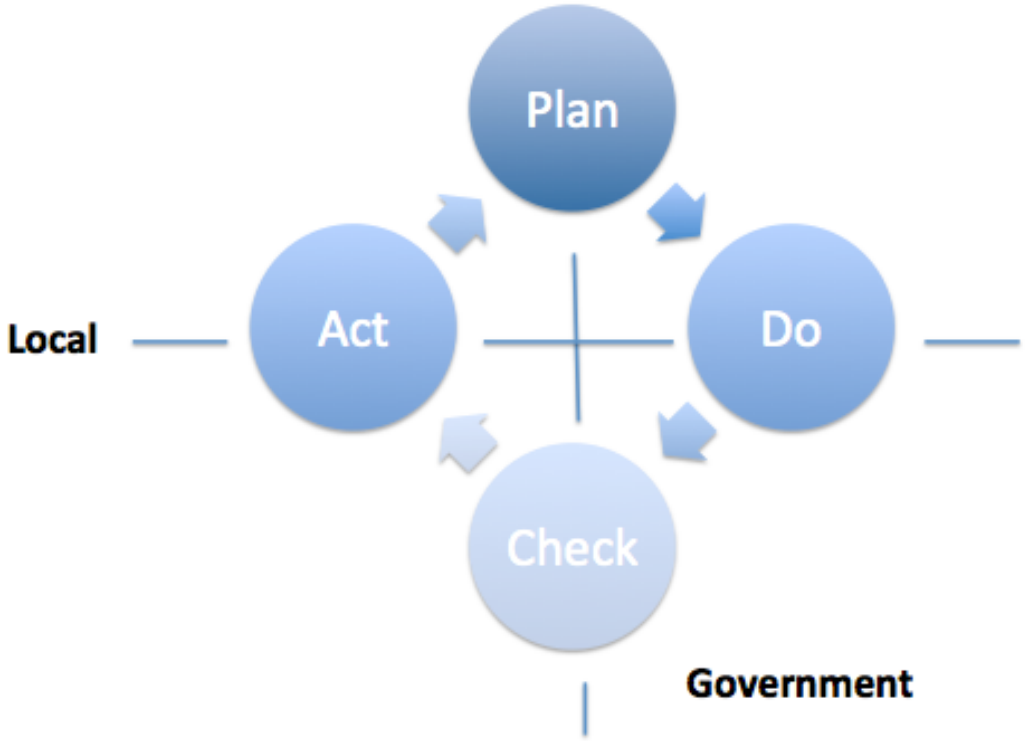

Figure 7: Plan-Do-Check-Act framework where the government is responsible for the top-down planning , support, and monitoring and the community takes ownership, in a bottom-up approach, of the responsibility for the implementation, operations and maintenance, and continuous improvement of environmental management.

4. Case Studies and Field Experiences

San Marcos, Ancash, Peru

The Municipality of the San Marcos District of the Province of Ancash in Peru (working under Peruvian legal/institutional framework) successfully set up a Municipal Department of Water and Sanitation in 2005, which represents an improved vertical-level scenario of adequate physical infrastructure planning and implementation. This entity is responsible for providing technical and administrative support, as well as running educational campaigns. The department was staffed with an environmental engineer and three technicians. The unit was supported by the Canadian WUSC organization. The outcomes of their intervention are included Table 7.

Table 6: Outcomes of WUSC Intervention in Ancash, Peru

Item	Objective	Achieved
1.	Creating a Municipal directory of existing Water Committees (JASS)	22 JASS formalized (3 registered with Public Registry)
2.	Recognizing new Committees	151 Committee members registered
3.	Supervision and Evaluation of Water System Management	17 committees improved financial management capacity; 9 committees elected new directive members
4.	Supervision and evaluation of the technical operation and maintenance of the physical infrastructure	3 water system rehabilitation proposals, 6 rural sanitation proposals including 5 schools
5.	Managing User Claims/Complaints	N/A
6.	Training of committees, technical operators, community health promoters, and local leaders	30 trained and certified technical operators
7.	Supervision and Evaluation of hygiene habits	6 Socio-Sanitary studies in 13 rural communities; 3 educational campaigns including monitoring water quality in 5 rural schools; Training of local community stakeholders

Lessons Learned Case Study (Ancash)

According to the legal mandate of the local representatives of the health ministry and the municipality, the socio-economic sustainability of rural sanitation services and infrastructure lies in the strengthening of local institutional support. The focus of this intervention remained on strengthening the liaison between the local health representatives responsible for the monitoring of water quality and the local governmental representatives responsible for technical and administrative

support, providing an appropriate small-scale support network for rural water system management.

Analysis

This intervention focused on a local level hierarchy by building a relationship between the local government and the volunteer committees or JASS, in the area. The Municipal Water and Sanitation Department helped the communities evaluate their existing infrastructure, identify needs for expansion, rehabilitation, or new infrastructure, and draft proposals for governmental subsidies. They also sought to build local capacity in terms of institutionalizing administrative knowledge by formalizing processes and strengthening and supporting organizational efficiency. The institutional framework for support of the water committees in the region is depicted in Fig. 6. This case study focuses on the vertical level hierarchy of the water system management and its overall governance, with minimal emphasis on the physical infrastructure of the water systems, save for the need for the ongoing training program for technical staff for the operations and maintenance of the systems over time.

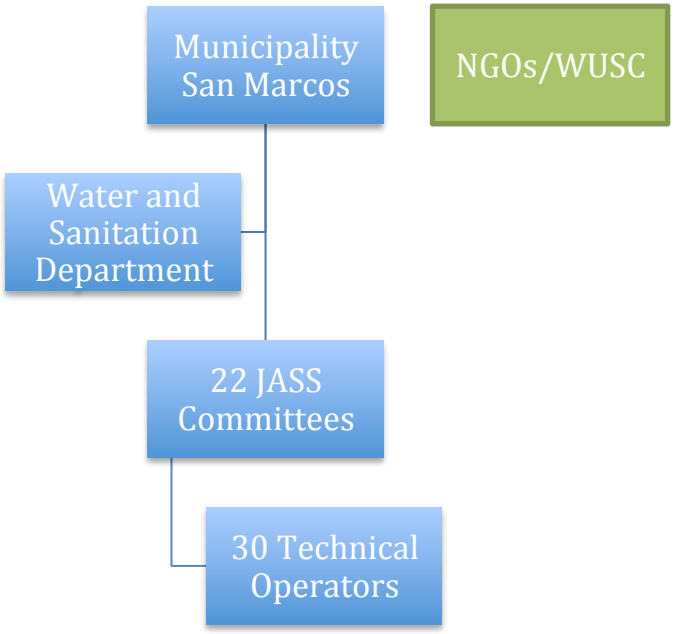

Figure 8 Institutional Framework Ancash, Peru

Previously, training efforts in the Community Management model have failed due to lack of turnover of information with the change of committees. This means that in order to make this a sustainable solution, a network of pertinent organizations that can provide continual technical support in the various functions of the water committees is necessary. Therefore, once Municipal and other organizational networks are established, a baseline diagnostic was conducted, the results of which will be analyzed in this report. This initial diagnostic made all parties aware of the current reality and needs of the communities. The project scope was defined according to these results and the capacities and competencies of the respective organizations and institutions involved.

Palpa, Ica, Peru

The province of Palpa has two different categories of water systems and respective administrative models, as defined by the Peruvian government. Population sizes under two thousand are considered rural and are held to a Community Management (CM) model of water committees. The CM model relies on the goodwill of a nominated volunteer administrative committee and a technical operator that is sometimes paid a fee.

The urban center of the town itself has a public company (EMAPICA) in charge of the administration of water extracted from two wells and an additional gravity fed intake without metering. This company is accountable to the National Sanitation Services Superintendence (SUNASS). The company is required to have a work plan and monthly fee based on a yearly budget, which is monitored by SUNASS. They currently operate a chlorine gas injection treatment system for the well water and distribute the water from 6am to 8pm during the rainy season with an additional break from 2pm to 5pm during the dry seasons. It is also responsible for the currently defunct operation and maintenance of wastewater treatment for the town center.

The rest of the province consists of rural water systems, both well and gravity-fed, providing water access directly to the homes without metering and

management by water committees. These communities currently have water access anywhere between 2-3 hours every other day, to every 10 to 15 days during the dry season. Most of the rural systems were built less than 20 years ago by a Canadian organization, the Worldwide University Service of Canada (WUSC). This organization helped form the initial committees and trained the participating members in the administration, operation, maintenance of the system, and treatment methods. This information was lost over time, however, due to turnover rates.

Palpa

The district of Palpa, Peru is a large rural town and the capital of the province of the same name, with a population density of 50 people/km² (INEI, 2007). The larger part of the population is concentrated in illegal settlements of makeshift homes made of woven reeds with limited access or legal rights to public services. The informal settlements gather water from irrigation canals and wells, as the river runs dry for more than half of the year. Small informal water systems have been built over time, often without the corresponding wastewater facilities, and are administrated by volunteer water committees. There are many such settlements in this district. Over time, these homes have become more permanent, built of sturdier materials, coming under the jurisdiction of the district once the community organizes and requests services, roads, electricity, water, etc. The main town center is serviced by a formal public-private service provider, as dictated by Peruvian legislation for populations exceeding 2,000 inhabitants.

Vizcas-Carlos Tijeros

This water system was also built by the Canadian governmental agency, World University Service of Canada (WUSC), in the early 1990s. This system is unique in that it services communities across two districts, Palpa and Llipata, which makes petitioning for governmental maintenance subsidies a diplomatic hurdle.

This is a gravity spring-fed system with reservoirs for each community. They use a manual system for treatment with liquid chlorine contingent upon the availability of materials, or when expecting health inspections from the local representatives from the Ministry of Health. The community currently has water service for two hours every other day. When supplies are depleted the community carries water from local irrigation ditches once the local river runs dry, which incidentally is half of the year. This system also services the largest population of any in the Province, at 618 users in 6-8 communities. The water committee that runs this system is formally recognized and active, requesting government subsidies for the rehabilitation of the system. The President of the water committee at the time of this study was one of the original participants in the construction of the project and tells of its evolution, noting the capacity building and population growth issues which have yet to be resolved. This demonstrates that it is because of the involvement of key figures in the community that some semblance of the original management framework remains.

Sacramento

This water system is located in the district of Palpa, also sourced by a gravity-fed water system built by WUSC in the early 1990s. A formalized water committee suggested by WUSC, according to the specifications of the founding charter, manages the system. They currently have a supply of two hours per day.

Arenales

This is a small community of 10 households, in the district of Llipata, with an electric pump and well that was manually excavated by the community, providing service to the homes via a spigot outside each of the homes. They run the pump 2 to 3 times a day despite the cost of fuel for the electric generator. The health inspector does water treatment demonstration manually once a month with each committee though the evidence suggests that there is no continuous water

treatment. The community, which administers and operates the system, is in need of training on water treatment methodologies.

Additionally this community was a beneficiary of dry-composting latrines project from the Municipality of the District of Llipata. The design was modified in a way that rendered them not fit for purpose. The double-chamber composting latrines for alternating use were altered to single chamber, insulated pits. This meant that the latrines could not be used neither as regular septic latrines nor as composting pits with the option to isolate the fecal matter for the recommended 6 months for anaerobic decomposition.

Tambo

This is a rural community situated in the mountains of the district of Palpa where the lack of road infrastructure limits access. The Municipality of the District of Palpa built a gravity-fed water system in 2012. The community does not pay a maintenance fee but provides maintenance service as needed on a volunteer basis.

Rio Grande

The Rio Grande river valley of Palpa, Ica, Peru is the most fertile river valley of the Rio Grande watershed. This is in part due to the fact that while its tributaries tend to dry up during the dry seasons, the Rio Grande maintains moderate to high water levels throughout the year.

The district of Rio Grande is serviced by four different water systems: the Rio Grande system built by the Canadian governmental agency, World University Service of Canada (WUSC); the San Jacinto-Paucarrastro-La Rancheria-Sta Rosa system, also built by WUSC; and two smaller systems, San Miguel and La Pernil-La Florita. The two smaller systems service smaller dispersed populations

and have not been taken into consideration for this study. The main system in Rio Grande has received US federal funding through Small Projects Assistance grants to replace a large part of the deteriorated pipes as well as governmental funding to build an additional spring box in order to increase water access.

Santa Cruz

The district of Santa Cruz in the Province of Palpa, Peru is a rural community with a dispersed population serviced by three different potable water systems. The main system that serves the larger part of the district was built by the Canadian governmental agency, World University Service of Canada (WUSC). The two other systems are smaller government subsidized projects, one a gravity-fed water system, the other a pump-operated hand-dug well. The two smaller systems serve a population of less than 20 households and do not currently have any formalized management models. This area has very few paved roads though there are increasing efforts to improve road access are in the works.

This main population of Santa Cruz was serviced by a hand-dug well with a donkey-powered pulley system at the time that the Canadian organization first arrived in the area. This is an interesting example of potable water service because it is situated in the most arid zone of the entire province, and hence more susceptible to drought and general water scarcity issues. Unlike other communities, it proved difficult to discover which people in the community stepped up to assume leadership roles in this collaboration. It is obvious that the community was able to fulfill the requirements of WUSC for demonstrating improved hygiene practices in the home. Some of the behaviors that were sought by WUSC were the corralling of animals and not having animals (chickens, guinea pigs, etc.) inside of the home, as was formerly the practice, as well as the construction and use of dry pit latrines that are still in use as a sanitation

technology in the area today. In 1992, WUSC initiated construction of a gravity-fed water system. In 2010 the Regional government addressed the intermittent water supply in the region by implementing a pump-operated well. The pump is currently not in use due to exorbitant energy costs to keep the electric pump in operation.

Figure 9: Maintenance of system involves cleaning, repairing, and locking of access points (photo taken by author in Santa Cruz, Palpa 2012)

During the construction of this system the engineer supervising the project was able to identify two men from the community who distinguished themselves in their ability to grasp the technical requirements of the system and were trained to be the technical operators. One of these men remains in the community to this day and is currently working as a system operator.

The community was required to provide in kind contributions by of materials and manual labor, for which reason there is a noticeable feeling of ownership regarding the system. The original members of the community are the main stakeholders for this project, where new families moving to the area were required to sign on as third party beneficiaries. This means that while that they have to pay for connection rights an equivalent sum to the manual labor work hours put in by the others, where a uniform number was required by all households or contribution in-kind in the provision of either meals, materials, or monetary contribution to make up the differences. The main stakeholders make up the general assembly and are supposed to be considered when any major changes are made to the system or the management. However, the members of the community that were not present for the construction of the system are rarely asked to participate in the decision-making meetings, and their responsibilities are limited to paying their monthly quotas.

The community was organized using a community management model that dictates that a previous administration trains the following committee, as mandated by their founding charter, but the trickledown of information is incomplete in even the best of circumstances. It proves difficult to fill the positions of the volunteer administrative committee because they are often faced with unwillingness to pay due to insufficient service or just outright defiance. Presidents of the committee report difficulty in assuming a leadership role in a community that is apathetic when it comes to taking action to improve their personal quality life.

The monthly quota has barely increased over the years. The well built by the regional government is out of commission due to overwhelming operating costs, and there may be something wrong with the pump itself. The system initially was able to provide the community with continuous water supply but over time the combination of population growth and the changing behaviors towards water use,

due to the improved standard of living, which resulted from access to water in the home, rendered it insufficient. Water use has increased as bathing, grooming and increased hygiene have become more frequent, and people have begun to use it for the maintenance of small gardens, and to provide drinking water for animals, or for watering down the dirt roads and yards to reduce dust. Aside from the social aspects that lead to less access, there are the technical aspects of the deterioration of the infrastructure over time due to improper maintenance, including the mudslides that wash away pipes, the depleted aquifers in the dry seasons, and scaling in the pipes which makes for a smaller diameter, reduces the water pressure. There are storage tanks for each community, from which the water operator may provide access to sections of the water system for allotted time periods. All of these factors combined mean that over time the community has decreased access to water going from 24hrs a day to 2 hrs every 5 days, at the beginning of the observation period, and then to 2-4hrs every day with a change in the administration. This improvement is due to the more rigorous control of rationing the water per sector and a second operator implemented by the new water committee.

When water service becomes intermittent, the community is required to store the water, generally in recycled oil tanks or large plastic garbage bins. This has significant implications when it comes to water quality and general public health because it is customary to drink straight from these bins, and only some families boil and store the drinking water separately as recommended by local health officials. The system provides the community with spring-fed water that is generally free of contaminants at the source but can become contaminated by random exposure to external elements, for which reason local health officials recommend the chlorination of the water system. The community lacks the appropriate technology to treat an intermittent water supply in a consistent manner aside from less reliable manual methods. Any residual chlorine that can provide protection from bacteriological growth evaporates over time when the

water is stored in uncovered containers, as is the norm. Thus with intermittent water supplies, point-of-use treatment and proper storage practices (in covered receptacles) are often stressed but difficult to enforce as a permanent behavior change in the home.

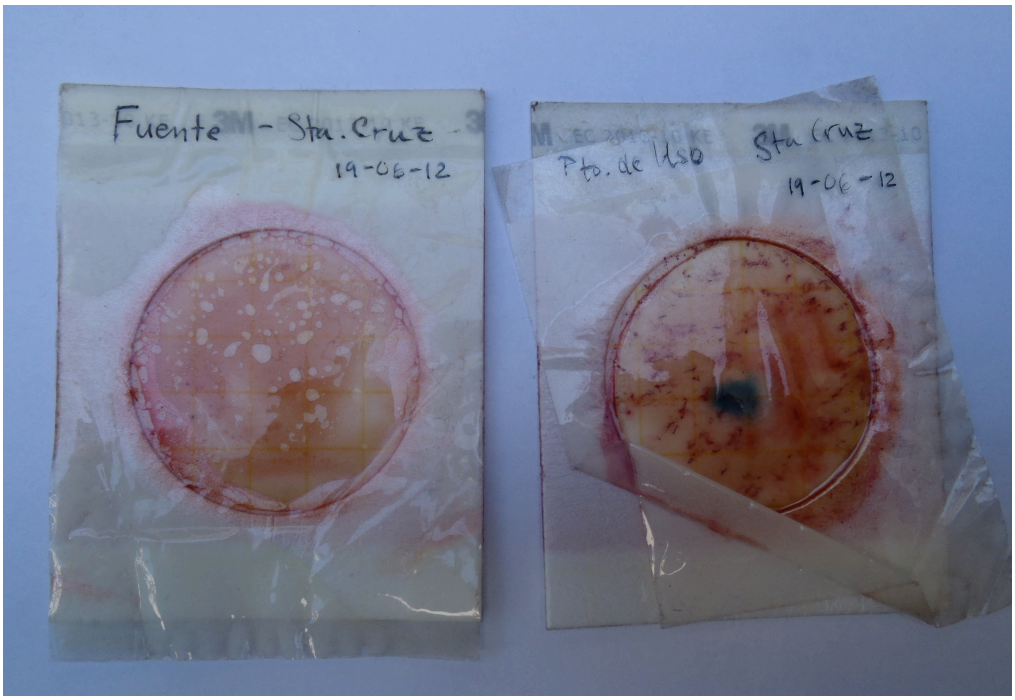

Figure 10: Petrifilm results (photo taken by author in Santa Cruz, Palpa 2012)

In Fig. 9, the results of a 3M coliform and E. coli petrifilm test are visualized. These portable petrifilms need to be incubated for 24 hours for coliform results (the red colonies) and 48 hours for E. coli results (blue colonies), (3M, 2011). These are great tools for visualization, but the method of incubation and sampling makes for use as indicator rather than actual quantitative results. The petrifilm on the left is a sample from the spring box for the Santa Cruz system which shows no signs of contamination, and on the right is a sample from a water storage receptacle in one of the homes that demonstrates a presence both red and blue colonies, ie. both E. coli and coliforms. This provides an ideal visual to communicate to the communities the need for improved point of use storage and treatment methods.

Diagnostic

Representatives from the provincial water quality representative for DIRESA then assessed the main water systems providing access to rural areas and a municipal employee designated as responsible for provincial water and sanitation. This is the first step in getting the committees formally recognized by the municipalities. Table 8 demonstrates that of the 10 systems included in the assessment, only 4 have been recognized as formal not for profit community organizations. The remaining organizations do not appear in national public records.

Table 7: Registration Status JASS, Palpa Province, 2012

No.	Organization	District	SUNARP
1	Junta de Usuarios de Agua Potable y Saneamiento – Sta. Cruz	Sta Cruz	No. 11031818 Active
2	Junta Administradora de Agua Potable – Pueblo Nuevo	Palpa	–
3	Junta Administradora de Servicios de Saneamiento – Piedras Gordas	Llipata	No. 11016002
4	Comité Agua Potable – Arenales	Llipata	–
5	Asociación de Servicio de Agua Potable y Saneamiento (AUSAPSA)	Rio Grande	No. 11019535 Active
6	Comité de Administración de Agua Potable Rural Vizcas-Carlos Tijeros	Ll-Palpa	–
7	Asociación de Usuarios del Sistema de Agua Potable del AAHH Sacramento-Palpa (AUAPAHSA)	Palpa	No. 02026774 Committee 2004
8	Tambo	Palpa	–
9	JASS San Jacinto–Paucarrastro–La	Rio	–

	Rancheria–Sta Rosa Republica de Canadá Rio Grande, Palpa	Grande	
10	Municipalidad de Tibillos	Tibillos	NA

Table 9 shows that the rural provincial monthly quota is between approximately USD $1-2.50, with an exchange rate of 1USD to 3.09 Peruvian Nuevos Soles according to the UN Treasury rate of exchange, (Treasury, 2015). This means that they have a monthly operating budget ranging from approximately USD $30 to $870. One of the systems does not currently collect a quota, relying on community volunteers for operating the system and collections or governmental subsidies for water treatment and system maintenance when necessary.

Table 8: Number of Clients, Monthly Quota (Palpa, 2012)

No.	**Organization**	**Clients**	**Monthly Quota**	**Total**
1	Junta de Usuarios de Agua Potable y Saneamiento – Sta. Cruz	255	S./6	S./1530
2	Junta Administradora de Agua Potable – Pueblo Nuevo	31	S./5	S./155
3	Junta Administradora de Servicios de Saneamiento – Piedras Gordas	46	S./5	S./230
4	Comité Agua Potable – Arenales	10	S./5	S./50
5	Asociación de Servicio de Agua Potable y Saneamiento (AUSAPSA)	384	S./7	S./2,688
6	Comité de Administración de Agua Potable Rural Vizcas-Carlos Tijeros	618	S./5	S./3,090
7	Asociación de Usuarios del Sistema de Agua Potable del AAHH Sacramento-Palpa (AUAPAHSA)	480	S./5	S./2,400
8	Tambo	17	–	–

9	JASS San Jacinto–Paucarrastro–La Rancheria–Sta Rosa	200	S./4	S./800
10	Municipalidad de Tibillos	30	S./3	S./90
	Total	**2071 households**		

Whereas continuous service is defined as 24 hours a day of water, only three of the 10 systems provide continuous water access, with the worst instance of water access being 15 minutes of water per day per household or 2 hours of water every other day, as outlined in Table 10. These communities require proper household water storage and treatment solutions and should be prioritized for subsidies for infrastructure rehabilitation or reconstruction. The majority of the communities in this region, being a desert region with scarce surface water, are served by gravity spring-fed water systems, with only one of the ten communities being serviced via a well with a generator powered electric pump.

Table 9: Infrastructure and Service Continuity

No.	**Organization**	**System**	**Year**	**Service**
1	Junta de Usuarios de Agua Potable y Saneamiento – Sta. Cruz	Gravity-fed + well	1992	2-4hrs/d
2	Junta Administradora de Agua Potable – Pueblo Nuevo	Gravity-fed	2005	15min/d
3	Junta Administradora de Servicios de Saneamiento – Piedras Gordas	Gravity-fed	2002	24hrs/d
4	Comité Agua Potable – Arenales	Well with Electric Pump	2009	2-3veces/d
5	Asociación de Servicio de Agua Potable y Saneamiento (AUSAPSA)	Gravity-fed	1994	24hrs/d

6	Comité de Administración de Agua Potable Rural Vizcas-Carlos Tijeros	Gravity-fed	1995	2hrs/every other day
7	Asociación de Usuarios del Sistema de Agua Potable del AAHH Sacramento-Palpa (AUAPAHSA)	Gravity-fed	1993	2hr/d
8	Tambo	Gravity-fed	2010	24hrs/d
9	JASS San Jacinto–Paucarrastro–La Rancheria–Sta Rosa	Gravity-fed	1993	6hr/d
10	Municipalidad de Tibillos	Gravity-fed	2000	12hrs/d

The larger water systems currently have at least one full time water technician to tend to the daily operation and maintenance of the system, whereas the rest of the communities rely on a technician on an as-needed basis, and the smallest of which have a rotation of volunteers as depicted in Table 11.

Table 10: Administrative and Technical Staff

No.	Organization	System Operator	Work Hours	Monthly Salary	Admin	Work Hours Admin	Salary Admin
1	Sta. Cruz	2	4hr/d	S./400	1	1-2/mo	S./400
2	Pueblo Nuevo	1	15min/d	S./50	–		
3	Piedras Gordas	–			–		
4	Arenales	–			–		
5	AUSAPSA	1	FT	S./700	1		S./365
6	Vizcas-Carlos Tijeros	1		S./800	1		S./750

7	AUAPAHSA	1	FT	S./1000	–		
8	Tambo	–			–		
9	Sta Rosa	–			–		
10	Tibillos	1			1		

These communities maintain vastly varying levels of formalized documentation (Table 11), hiring the services of an accountant on a monthly basis to help balance the books and advise on additional expenditures.

Table 11: Documentation for Water Supply Management

No.	Organization	Meeting Minutes Book	Yearly Work Plan	Yearly Budget	Balance Sheet
1	Junta de Usuarios de Agua Potable y Saneamiento – Sta. Cruz	X	X	X	X
2	Junta Administradora de Agua Potable – Pueblo Nuevo	X			
3	Junta Administradora de Servicios de Saneamiento – Piedras Gordas	X			
4	Comité Agua Potable – Arenales	X			X
5	Asociación de Servicio de Agua Potable y Saneamiento (AUSAPSA)	X	X	X	X
6	Comité de Administración de Agua Potable Rural Vizcas-Carlos Tijeros	X	X	X	X
7	Asociación de Usuarios del Sistema de Agua Potable del AAHH Sacramento-Palpa (AUAPAHSA)	X			X
8	Tambo				
9	JASS San Jacinto–Paucarrastro–La Rancheria–Sta Rosa	X			
10	Municipalidad de Tibillos				X

This initial assessment of the water system management provides the overview of the current situation in the Province of Palpa. Using this information to compare the requirements of the various communities, the local government will then be in a position to provide the best possible support and subsidies, once the level of need and the feasibility of their investment are determined.

Qualitative Comparative Analysis

Using the information obtained in this diagnostic phase, it is possible to build binary truth tables, as outlined by Ragin (1987), in order to determine any patterns in the data, and have a closer look at the needs of rural water system management in provincial Palpa, Peru. These truth tables use all ten systems under observation, narrowing down the constraints to those most relevant to the overall performance of the systems as follows: population served, age of the physical infrastructure, continuity of service, paid technician, and legal recognition. Of all of the constraints, the measure of water service continuity in relation to the population served and the age of the infrastructure are most telling. Table 11 tests the hypothesis that water systems with a larger distribution network (greater than 100 households) are older, more formalized and therefor more successful in their water management due to their longevity.

Table 12: Truth Table Overall Performance

Constraints	A	B	C	D	E
System	Households served >100	Age System >20yrs	Continuity =24hrs/d	Paid technician	Legally recognized
1	1	1	0	1	1
2	0	0	0	1	0
3	0	0	1	0	1
4	0	0	0	0	0
5	1	1	1	1	1
6	1	1	0	1	0
7	1	1	0	1	1
8	0	0	1	0	0

9	1	1	0	0	0
10	0	0	0	1	1

This first truth table allows for a broad look at the systems, where exactly half of the systems serve a population greater than 100 households. Of these there is a direct correlation with the oldest infrastructure serving the largest populations, and the newer systems serving smaller populations. It is also possible to observe that system 5, corresponding to the Rio Grande AUSAPSA committee, is the best performing system being the only system to account for all five criteria. It is also worth noting that of the 10 systems under observation, only three of the systems are able to provide adequate water service (i.e. 24 hours of service) (McIntosh, 2003) This is where this logical binary comparative analysis falls short, since while most of these systems provide water access every day or every other day, 15 minutes of water twice a day is not the same as pumping water from the well two to three times a day; and two hours every other day is not the same as two hours of water service every day. This methodology allows for partial or “fuzzy set” representation of data, using decimal values between zero and one, which could perhaps account for this disparity, but the small data set would not allow for fuzzy-set analysis.

The following truth table is redundant in that it displays the opposite outcome for a better overview of the overall performance of smaller systems. This truth table makes the opposite assumption: that water systems serving smaller populations are less successful by looking at the performance of systems serving a population with less than 100 households and demonstrating an inverse relationship with the age of physical infrastructure, all being less than 20 years old. Two out of the five smaller systems provide the recommended 24 hours a day of water service; these two systems are Piedras Gordas (System 3) and Tambo (System 8).

Table 13: Truth Table Small Communities

System	A	B	C	D	E
Constraints	Households served <100	Age System >20yrs	Continuity =24hrs/d	Paid technician	Legally recognized
1	0	1	0	1	1
2	1	0	0	1	0
3	1	0	1	0	1
4	1	0	0	0	0
5	0	1	1	1	1
6	0	1	0	1	0
7	0	1	0	1	1
8	1	0	1	0	0
9	0	1	0	0	0
10	1	0	0	1	1

These two cases are unique in their provision of adequate service due to different constraints. It is worth noting that Tibillos can provide adequate service at 12hrs a day because their water system is currently under the direct administration of the district Municipality with a full time water operator subsidized by the local government. On the other hand, Tambo is a small community with a gravity fed water system built in 2010, which accounts for the 24 hrs of continuous water service. Despite their lack of organizational support, the new physical infrastructure does not yet show the wear of lack of proper maintenance and support from a volunteer-only operation. Finally, Piedras Gordas is a mining settlement on the outskirts of the province whose operation and maintenance of the physical infrastructure is subsidized by the mining operations.

These findings suggest that these bigger systems, once formalized and trained can bear the responsibility for the autonomous management of their water services, while the smaller communities will require further support.

Horizontal Level Perspective

From the point of view of infrastructure and the project development phases, there is access to the necessary technology for the capture and public distribution of water in the coastal region of Peru. This is not the case in the more remote Andean or Amazonian villages though outreach programs increasingly cover more of this area. The geographical constraints beg clarification in that this paper addresses needs unique to the arid coastal region, which has much more access to resources and support due to ease of transport and communication. Water systems tend to be designed, or rather adapted, from existing blueprints from previous projects and so there tends to be uniformity both in the types of systems in use and the failures experienced by the systems. System collapse seems to be mostly due to weaknesses in the social dimensions of the administration, operations and maintenance of the systems, as outlined in the previous section.

In the years 1990-1995, the Canadian governmental organization World University Service of Canada (WUSC) worked on developing rural water access in the province of Palpa, Peru. Previously, the local population was using hand-dug wells for drinking water access. WUSC subsidized a percentage of the project design and construction, having locals provide matching contributions in materials and labor. Before committing to working with the communities, WUSC strove to establish behavioral changes with smaller scale projects in sanitation such as the corralling of animals and the construction and use of latrines for the improved commitment to community hygiene practices and sanitation.

Vertical Level Perspective

The formal founding charters of these community organizations provide for the training of the new administration by the preceding committees, meaning that while there is some trickledown of knowledge, twenty years later there are gaps in the information available, and the needs of both the communities and of the systems have changed over time. Their legal/institutional support network has also been changed, accountability passing from the National Superintendent for Sanitation Services (SUNASS) to the Regional Health Department (DIRESA) and

back to ultimately reside solely in the local government at present. Informal interviews with leaders in these institutions provide insight into the extent of their involvement, the differences in their approaches, and their perceived successes and failures in their interactions with the rural water community organizations with the modified and updated legal mandates to back up these transitions. Based on WUSC and other stakeholder institutions, the collapse in these systems is due to lack of proper involvement of the local governments, which allows for social conflict and the lack of proper commodification of water access through metering to interfere with providing the communities with adequate service.

Project Governance

The communities that were able to organize themselves to meet the standards established, led by a community leader (notably predominantly female leaders, who rallied the neighbors to get the projects approved) were the ones selected for larger subsidies to complete these water access projects. In an informal interview the engineer who oversaw the construction, now University professor in Lima, it was noted that the process of building the gravity-fed capture systems side by side with the community allowed the team of engineers to select the more apt candidates for extensive training in the operations and maintenance needs of the systems. Once the infrastructure was in place, WUSC worked with the community to establish a Community Management model that counts on a volunteer committee for the collection of a monthly quota and its investment. These were then legally recognized not-for-profit institutions, with certain tax exemptions, and they continue to exist in variable states of formalization.

Organizational and Legal Framework

The Organic Law of Municipalities (No. 27972) defines the role of the Municipality with regards to water and sanitation in Articles 73 and 80. This law was a product

of defining roles with decentralization efforts from Lima in the 1990s. It defines the shared responsibility of provincial and district governments in providing technical support for the administration, financing, and implementation of infrastructure pertaining to water and sanitation improvements. It also identifies the local government representatives as responsible for environmental conservation movements in their respective jurisdictions. The legislature requires the municipality to have an environmental management unit to oversee these efforts, when possible, (Peru, 2003) .

The General Law of Sanitation Services (No. 26388) defines roles of various entities with regard to sanitation quality and control standards. It places the Ministry of Health (MINSA) directly responsible for environmental quality testing and monitoring. It defines the municipality's need for a water and sanitation unit to support and monitor sanitation services. This law recommends the following frameworks for the administration of water systems, listed in Table 13, (Peru, 1994b).

Table 14: Peruvian Framework for Water System Management

Population	**Management Model**	**Suggested Payment Model**
X ≤ 2000	JASS	Quota (assigned)
2000 < X ≤ 15000	Municipality/OE	Quota (calculated)
15000 < X ≤ 40000	Service-provider (EPS)	Tariff (meters)
X > 40000	Service Provider (EPS)	Tariff (meters)

A JASS is a committee made up of volunteers from the community responsible for the administration of water and sanitation services. The monthly quota is chosen by vote during the general assembly. A specialized operator (OE) model,

consists of a trained and competent technical operator and administrative staff under direct Municipal management, as recommended by the National Rural Sanitation Program, which would be well suited to the larger rural water management systems. However, this model takes away the ownership of the water and sanitation services from the community and has been largely rejected as a proposal in the Province of Palpa. The data from the case study shows that it is the smaller rural systems that require Municipal support for successful management, and so it is recommended that the advised models be reversed, where larger rural systems are handed over to formalized non-profit community-managed JASS and smaller rural systems are under the direct responsibility of the local government.

The Water Resources Law (No. 29388) creates the National Water Authority (ANA) in order to spearhead watershed protection efforts in the country. It outlines the responsibility of cooperation for existing entities such as the MINSA and the local governments in the sustainable use of water resources and the creation of Watershed Management committees, (Peru, 2009).

Development Strategies and Initiatives

The Ministry of Housing, Construction, and Sanitation has a National Rural Water and Sanitation Program (PRONASAR) whose mission is to improve rural potable water access through capacity building in the Administration, Operations, and Maintenance of systems and the funding of infrastructure projects. Participation in this program requires a Municipal commitment in order to guarantee the sustainability of the intervention efforts. Their involvement is solicited in the second stage of the project. Their intervention strategy is as follows, (PRONASAR, 2015):

- Identification of intervention parameters for the project in terms of service characteristics that guarantee minimum acceptable conditions for quality of life for the population of users.
- Definition of potential cities involved in the project based on the focused response to the demand.
- Educating the civilians and Municipality on the project in order to achieve their inclusion and voluntary participation in the different phases of the project.
- Building local capacities that support the intervention process and guarantee the sustainability of the service over time.
- Educating the clients, technical operators, the municipalities, and other stakeholders of the project on their roles, duties and responsibilities with the service.
- Participatory identification of a management model and operational characteristics best suited for the city.
- Investment in the rehabilitation of the systems as a means to comply with the goals of the project, in terms of intervention parameters.

The National Superintendent for Public Registry (SUNARP) provides legal recognition of property and organizations, allowing them to exercise their legal rights and formally request technical and financial support, governmental subsidies, etc. The JASS are recommended to register the organization and each newly elected committee with the SUNARP, thus allowing them legal representation, (Peru, 1994a).

The National Superintendent for Customs and Tax Administration (SUNAT) legalizes any financial interactions, enforcing transparency and the legal right to banking and loan applications. It is recommended that JASS register with the SUNAT, though as non-profit organizations they will be exempt from taxes. They will benefit from complimentary trainings and technical support from SUNAT representatives on financial matters, (Peru, 1988).

The Environmental Evaluation and Supervision Organization (OEFA) – in simplest terms, the Peruvian version of the US Environmental Protection Agency (EPA) – has been increasing its outreach by facilitating the creation of local chapters of the agency, (OEFA, 2015). The OEFA is a key player in the monitoring of performance and enforcement of environmental regulations.

Finally, the National Technical Learning Institute (SENATI) under the jurisdiction of the Ministry of Housing, Construction, and Sanitation, was created by Peruvian Law No. 13771 to support technical capacity building in various industrial endeavors, including the installation, repair and maintenance of mechanical equipment and physical infrastructure for water and sanitation. The institute is staffed by professors from public universities who are registered with the National College of Engineers, (Peru, 1961). SENATI is an important stakeholder in the sustainable formalization of rural water and sanitation management in that they are able to customize training programs to the needs of the community.

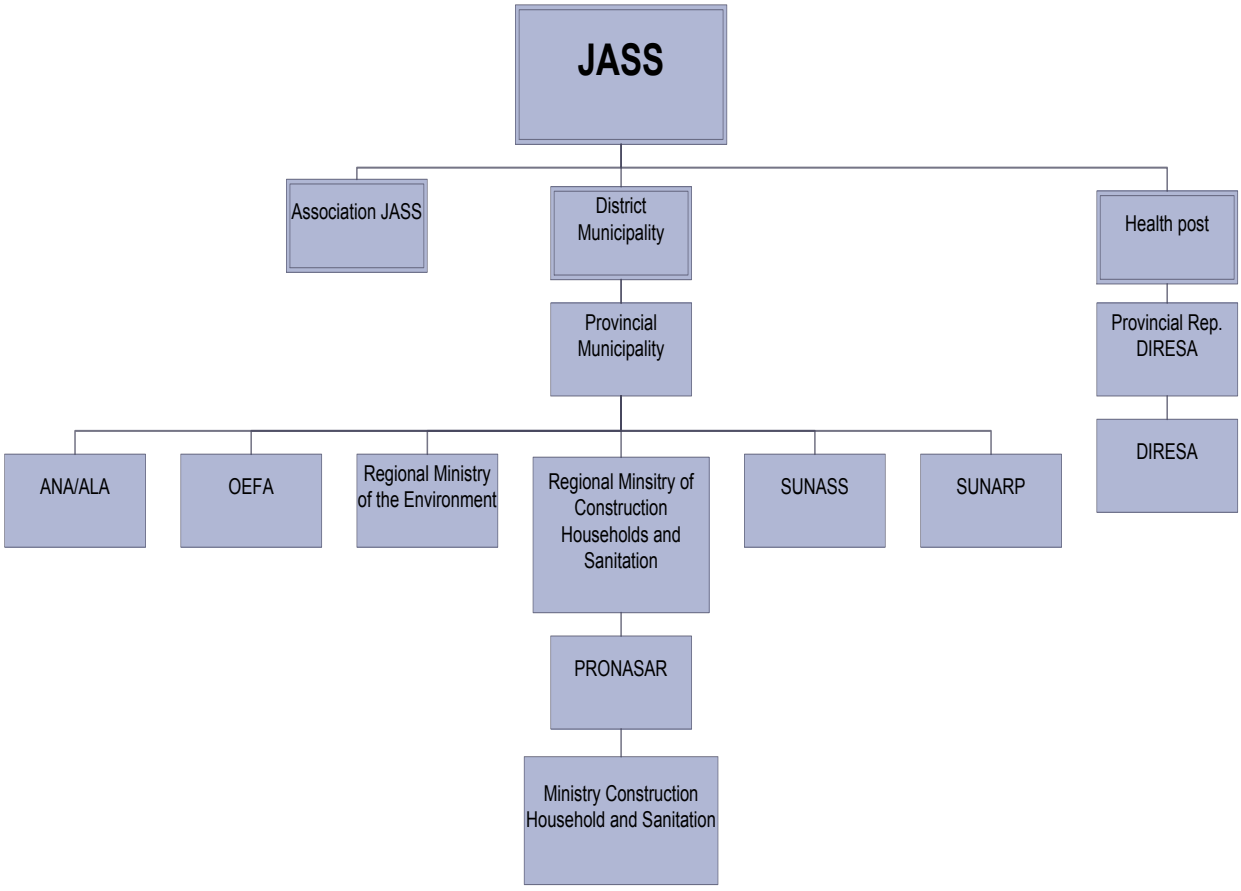

Figure 11: Institutional Framework for Rural Water Security Plan

Based on this research, the project efforts focused on creating the institutional support network for increased accountability and legalization of the management models for the different communities. This would have a basis for coordination within the local Municipalities. The Provincial and District Municipalities of Palpa collaborated with local health representatives on creating a baseline diagnostic of the administrative practices of rural water system management. This led to creating a directory of the local water management committees, a database of contact information and the first official means of communication and database of water and sanitation metrics for the province.

Using this information the Municipality was then able to coordinate a provincial Water Security Plan including a cost estimate from the Institute affiliated with SENATI for an ongoing training and certification scheme for technical operational staff. This Provincial Water Security Plan of Action compiled by the author for the

Provincial Municipality made provisions for liaising with the various institutions for ongoing support in water resource management and water quality monitoring, and financial education for newly inducted committees.

Table 15: Environmental Management System Requirements in Peru

Item	System Requirements	Peru
4.2	*Environmental Policy*	National environmental legislation
4.3	*Planning*	Provincial Rural Water Security Plan - Palpa
4.3.1	Environmental Aspects/Impacts (HIRA)	Water Resource Management – ANA/ALA
4.3.2	Legal Requirements	Municipal Environmental Management Unit
4.3.3	Objectives, Targets, Program	Provincial Rural Water Security Plan
4.4	*Implementation and Awareness*	
4.4.1	Resources, Roles, Responsibility	Stakeholder Map
4.4.2	Competence, Training and Awareness	Water System Technician Training and Certification - SENATI Administrative Training - SUNASS
4.5	*Checking*	
4.5.1	Monitoring and Measuring	Water Quality Monitoring - DIRESA
4.5.2	Evaluation of Compliance	OEFA

Table 15 outlines how the combined efforts of the Provincial Rural Water Security Plan to be implemented by the Provincial Municipality with support from various national stakeholders will provide some of the key aspects of the planning, monitoring of performance, and corrective actions required by the international standard for environmental management.

United Nations Office for Project Services

An internship with the Health, Safety, and Environmental (HSE) Management team at UNOPS, from June 2014 to March 2015 was turned into a co-op educational experience through Michigan Technological University's program for university credit. This entailed regular progress reports from the HSE Manager and internship supervisor. This department entailed a two-person team at Headquarters with the Sustainable Infrastructure Practice Group, in Copenhagen, Denmark, providing planning and implementation support to participating field offices and addressing the gaps in the management systems as outlined by ISO14001 requirements for Environmental Management Systems. This will be addressed in the report because the environmental components of this experience were informed by the organizational management work done in Peru.

The Environmental Management System (EMS) for UNOPS is founded on the Organizational Directive No. 40, effective January 2013. This directive compels UNOPS operations to do design and construction in an environmentally conscious manner, avoiding pollution and minimizing environmental effects, and in compliance with local, international, and organization environmental requirements, (UNOPS, 2013). Construction site practices encouraged by the EMS include daily/weekly inspections, waste management, storage/disposal of hazardous waste (i.e. asbestos, contaminated oil, etc.), the handling of concrete washings, borrow pit management, emergency preparedness (i.e. spill kits and visible procedures), dust and noise control, and ecological and archaeological considerations.

Figure 12: Waste Management Practices in High Security Prison Project (photo taken by author in Pristina, Kosovo; July 2014)

At a headquarter level, the EMS requirements encompassed addressing any gaps in the system requirements identified by internal and external audits against ISO 14001 requirements. Some key areas for improvement that were addressed included the need for internal policies, templates, and guidelines for both incident reporting and checking for legal compliance.

Table 16: Environmental Management System Requirements for UNOPS

Item	**System Requirements**	**UNOPS**
4.2	*Environmental Policy*	**AI Incident Reporting**
4.3	*Planning*	
4.3.1	Environmental Aspects/Impacts (HIRA)	**Field Support**
4.3.2	Legal Requirements	**Field Support**
4.3.3	Objectives, Targets, Program	**Defined Scope for 2016**
4.4	*Implementation and Awareness*	

4.4.1	Resources, Roles, Responsibility	**Audit Schedule 2015**
4.4.2	Competence, Training and Awareness	**Trained Internal Auditors**
4.4.7	Emergency Preparedness and Response	**Incident Reporting Templates**
4.5	*Checking*	
4.5.1	Monitoring and Measuring	**Created Incident/Legal Req. Databases**
4.5.2	Evaluation of Compliance	**Check for Compliance**

The author created the organizational procedures for identifying relevant local environmental legislation in countries of service. This required an iterative process with established procedures for identifying environmental aspects and impacts of construction activities in a risk-based approach to environmental management. Local legislation aided in establishing the proper mitigation activities within the context of local institutional support, resources, and requirements. For example, when establishing a solid waste management plan for a construction site, it is necessary to identify key stakeholders and processes for the proper segregation, storage, transport, and final disposition of different types of waste. In establishing the protocol for incident reporting, a subject of a sensitive nature when fatalities or major spills may be involved, it was necessary to first draft an internal policy, or administrative instruction to compliment the organizational directive which establishes the EMS. This draft is currently under review before final submission and approval. The administrative instruction outlines the reporting hierarchy and is supported by a newly created incident reporting template and database created by the author. Creating new templates and guidelines is possible by a comparative study of informal templates and databases used by UNOPS contractors, coming from the private sector, who adopted quality control practices from previous organizations.

Another key aspect of audit findings of the external audit addressed by the author was the creation of a team of certified internal auditors, representative of the different regions of service, responsible for a culturally sensitive approach to monitoring and inspections. This strengthens the “Check” processes of the Plan-Do-Check-Act cycle. The internal auditors are trained to review both the documentation (i.e. Environmental Management Plans, inspections, incident reports, legal requirements, etc.) and site practices through a structured fact-finding method that supports the identification of room for improvement, or nonconformities with system requirements, and facilitates a conversation on corrective actions.

5. Conclusions

Achieving sustainability is a multi-sector effort, which is within reach in the developing world context. Robust Environmental Management Systems, as outlined in ISO 14001 standards, should include planning, legal requirements and checks for compliance, a clear definition of roles and responsibilities, training and certification, and a top-down/bottom-up approach. This report shares two field experiences that illustrate the strength of the Plan-Do-Check-Act cycle of a risk-based approach to environmental management, one through the Peace Corps service in the province of Palpa, Peru and the other through an internship with UNOPS at headquarters in Copenhagen, Denmark. The focus of the intervention in Peru was in the field of rural water and sanitation management. The intervention established a map of relevant institutional stakeholders in supporting community-level, not-for-profit water committees in taking ownership of and maintaining rural water distribution systems. The internship in UNOPS involved providing support to country offices in the implementation of the organizational Environmental Management System and addressing gaps in the system according to ISO 14001 system requirements at a headquarter level; creating supporting policies, templates, and guidelines.

This report has illustrated how institutional support can be achieved through case studies in Peru, establishing the vertical-level hierarchy of institutional support in key aspects of the sustainability of utilities management ranging from water resource management, water treatment, water quality monitoring, and ongoing training of technical staff. Using a combination of ethnographic and qualitative comparative analysis methods, it was possible to get a clear picture of the reality in the field and create causal relationships that permitted the grouping of the communities into different categories with specific needs in terms of support.

These case studies support Kaminsky and Javernick-Will's factors for sustainability in rural infrastructure by focusing on the software, or administrative needs, of the largely independent rural committees' management of their water supply systems, where the most important indicator was considered the

enforcement of government regulations. The case studies were then analyzed within the context of engineering project organization, looking at the hierarchical institutional support and supporting government regulations on a horizontal-level perspective, the needs of the physical infrastructure in place on a vertical-level perspective, and overarching governance themes related to water resource management and the settling of disputes as to appropriate water use.

The first case study is a review of the work done by the Canadian World University Service (WUSC) in the region of Ancash in Peru, where they were able to successfully formalize rural water supply management by liaising with the local government representatives and various national institutions. The same WUSC had intervened some 20 years earlier in the construction of gravity-fed water supply systems to the main rural settlements of the Province of Palpa in Peru, where it was possible to obtain first-hand ethnographic observations and lessons learned for the second case study. This second case study analyzes the current situation, using lessons learned from the first case study to replicate efforts in the formalization of water supply management and institutional support, thus creating a framework for future water and sanitation sector interventions in the region.

Additionally, the work with UNOPS further illustrates the requirements for the successful implementation environmental management systems. The continuous improvement of the UNOPS EMS requires direct communication with the field offices and the executive level of the organization, where the importance of system compliance is stressed as key processes to improve overall quality monitoring and control for best practices in a competitive market. The risk-based approach assures emergency incident mitigation and response that is essential for a strong reputational marketing strategy.

Access to water is a human right, and a water supply is considered successful if it provides 24 hours of continuous water services. The findings from this study have fields of application both in any instance of urban and rural development and utilities management. It is possible to use local legislation to empower local

communities to take legal ownership of their water systems by becoming legally recognized non-profit entities, thus achieving a stronger basis for negotiation with governmental and international aid agencies. The data from the case study shows that it is the smaller rural systems that require Municipal support for successful management and so it is recommended that the advised models be reversed, where larger rural systems are handed over to formalized non-profit community-managed JASS and smaller rural systems are under the direct responsibility of the local government. It can be concluded that while Peru currently has extensive regulation of water and sanitation services, it is lacking in implementation due to a shortage of human resources for enforcement activities. It is possible to successfully create a Water Security Plan of Action and facilitate a link between the responsible institutions for ongoing support on a local level.

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