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Clean Water for all?

A case study on the role of the D4field

water purification technology in a Peruvian rural community

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"If you could tomorrow morning make water clean in the world, you would have done, in one fell swoop, the best thing you could have done for improving human health by improving environmental quality"

William C. Clark, speech, Racine, Wisconsin, April 1988

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Jessica

Abstract

Poor water quality and lack of access to improved water services continue to be problems in developing countries such as Peru, with a stronger vulnerability in rural communities. Aiming to enhance practical knowledge through a case study in the rural community of Cuncani, this thesis explores why this community has not been able to obtain a sustainable and safe water supply and how a water solution such as the D4field could be sustainably implemented. Based on the theoretical frameworks on water governance, water resources management and sustainability principles for technological implementation, this research gathered data through interviews, a survey in the community and a focus group activity in order to develop a practical comparative analysis to identify key elements for the deployment of the D4field. This thesis finds that the current ineffective institutional arrangements together with cultural barriers such as low awareness on the relationship between water quality and health, low demand for improved water services, lack of acceptance to chlorination as current water treatment method and lack of a long-term vision; have hindered Cuncani from having a safe and sustainable drinking water supply. Furthermore, an effective institutional scheme with strong responsibilities placed in the community and the Municipality, will support the long-term sustainability of the D4field. However, entrepreneurs such as Watersprint AB would have a crucial role and additionally, this thesis suggests to explore the potential role of NGOs and local entrepreneurs as implementation drivers and to improve the effectiveness and sustainability of water services in Cuncani.

Keywords: safe drinking water supply, sustainability, health, water solutions, institutions, and entrepreneurs.

Executive Summary

Even though Latin America has a great variety of natural resources including water, and bearing in mind that in 2011 the United Nations (UN) declared water as a human right, the World Bank (2011) estimates that approximately 20% out of the 120 million people that live in rural communities in Latin America and the Caribbean still lack access to an improved drinking water supply. Moreover, as health is one of the elements that is directly affected by water consumption, poor water quality can promote waterborne diseases (WHO, 2007). Indeed, according to the WHO (2007), 1.8 million people die every year due to diarrheal diseases even though 94% of these deaths could be prevented through the increase of availability of clean water, improved sanitation and hygiene.

In addition, the importance of access to safe water was further acknowledged by the UN within the Millennium Development Goals (MDGs) by adding a target related to halving people without access to safe drinking water by the year 2015 within the environmental sustainability goal (UN, 2014). However, when it comes to Latin America and the Caribbean, there are countries that still have not met the aimed water access levels. In the case of Peru, the WHO & UNICEF (2014) indicates that by 2012 this country had a total coverage of improved drinking water supply of 87% with a rural coverage of 72%. Therefore, these numbers place Peru in need for more efforts to achieve the required access levels and related sustainability on water services.

In an attempt to contribute towards achieving a sustainable access to safe drinking water in the developing world, Watersprint AB has developed the D4field as an innovative water purification technology aiming to completely remove pathogens from water (K. Persson, personal communication, December 19, 2015). As it is a nano-based LED device that works with UltraViolet (UV) light and has a fair low electrical requirement, it is also part of the clean-tech innovations intending to be effective in meeting people's need while being efficient and environmentally friendly (Johansson et al., 2003). In spite of this, according to Johnson et al (2006), social, economical, political, cultural and technical elements must be considered in every different community if sustainability of water services is to be achieved when implementing any technological solutions. Finally, given that most of these communities are living in poverty conditions, the WHO and IRC (2003) state that a major concern is to find the technological and institutional alternatives in which users will be willing to pay together with the achievement of health and environmental sustainability.

Given the fact that rural communities are the most vulnerable in developing countries and in the interest of enhancing knowledge regarding access to improved water services in one of the countries with the lowest safe and sustainable water access in Latin America and the Caribbean, the present research work has as main objective to assess the factors influencing the deployment of a water purification solution in a rural community. This research also aims to enhance the understanding and provide practical knowledge around the key elements related to the sustainability of water services and technological implementation through the development of a case study in a rural community from a developing country. In order to achieve the objectives previously mentioned, the following research questions and sub-questions are to be answered:

1) Why has Cuncani been unable to obtain and maintain in time a safe and sustainable drinking water supply?
   - ✓ How does the current water system work in Cuncani? In terms of who are involved in the operation and management and how are responsibilities and costs allocated among the different actors.

- ✓ What are the main barriers constraining the safe drinking water access in Cuncani?

2) How can the D4field technology be deployed in Cuncani?
   - ✓ Which are the institutional and social structures, in terms of responsibilities and costs sharing, that can support not only the implementation but also the maintenance and long-term sustainability of the technology?
   - ✓ Which are the main drivers that can enhance both the implementation and long-term sustainability of the technology in Cuncani?
   - ✓ What are the key parameters that the technology will improve in Cuncani's members and in public institutions and organizations?

The methodology for the present thesis was structured in four main stages for data gathering and related analysis. The first stage consisted on a literature review on Cuncani's information and Peruvian legislation on water services provision together with informal interviews with the Non-governmental Organization (NGO) Nexos Comunitarios. The second stage included face-to-face interviews with the considered relevant stakeholders for this research. The third stage was based on a survey carried on in Cuncani and finally, the fourth stage included a focus group activity with the relevant stakeholders for this research. For the analysis of the findings from this thesis, a comparative analysis was carried on based on the identified by the author as relevant water governance and water resources management frameworks together with available literature on principles for the sustainability of water services and technological implementation. Key elements and principles were identified through a literature review and later used to enhance the analysis of the findings from this research work with a more practical approach.

This thesis finds that Cuncani has had water access since the year 2010 and the community has been able to obtain water trough the individual faucets installed in every household. Moreover, because of National directive from the Ministry of Health, the Municipality of Urubamba provided them with the entire infrastructure for implementing the current water purification method used, which is based in chlorination. Furthermore, the responsibility of operating and maintaining water systems in every community was attributed to the JASS or community water management board. However, this thesis finds that neither the *Juntas Administratdoras de Servicios de Saneamiento (*JASS*)* or Water and Sanitation Management Boards from Cuncani nor the Municipality are properly maintaining the chlorination system and as a result, 64.9% of the interviewed households reported suffering from stomach illnesses that might be attributed to poor water quality. Additionally, due to the dissatisfaction with their services, most of the households are not currently paying any monthly fee to the JASS board.

Among the constraining factors for the provision of a safe and sustainable water supply in Cuncani, this thesis discovers cultural barriers as a crucial element; in this sense, as cultural beliefs from community members are against the use of chlorine because of its chemical characteristics possibly jeopardizing people's health, Cuncani has promoted a strong resilience to maintaining their own systems. Thus, no sense of ownership and no trust in their water systems have been promoted. Additionally, this research finds that there is a fairly low understanding on the relationship between water quality and health; this can result in lack of demand for improved water services and lack of initiatives to seek for an alternative replacement method for chlorination. Furthermore, there is a strong tendency from communities to expect for external support instead of promoting sense of self-diligence and leadership among people. Finally, this thesis grasps that, as most people do not perceive an immediate tangible benefit from improved water services and as they have a fairly weak

education and training together with a low ability to retain knowledge and low awareness; these elements have promoted a limited willingness to pay for improved water services.

Relevant constraints are also related to the current ineffective institutional arrangements and the disaggregated stakeholders participation within water services provision; in this sense, main barriers are attributed to the limited availability of resources and capabilities from local authorities to perform their work properly. As a consequence, this thesis finds that there is limited monitoring in terms of water quality and lack of enforcement from the Municipality when it comes to guaranteeing a safe water supply in its communities. In terms of participatory elements, this thesis verifies that when it comes to the development of any project almost no women participation is given; therefore, strengthening women participation will play a key role by improving decision-making processes within communities through the involvement of women's perspectives on health and education, among others.

On the other hand, on the basis that Cuncani would need external support for affording the D4field or any other water-related technology, given that National legislation places a strong responsibility in Muncicipalities within services provision, this thesis finds that in the most convenient and fair participation scheme, the Municipality would play an important role by being responsible of facilitating and affording the technology. However, in order to enhance ownership and responsibility sense, the Community has also a key role by contributing with this investment but in a lower share, giving its lower availability of financial resources. In relation to the community and its JASS, they have a critical role in the decision-making process for any project. The JASS plays a fundamental function by being leaders, innovators, and communicators and has a strong responsibility within the operation, maintenance and monitoring of the community's water systems.

In addition, besides playing the role of providers of a technology, entreprenerus such as Watersprint AB, are also defined as key actors for training the JASS boards in order to guarantee the proper operation and maintenance of the technology. However, the author suggests that if the community agrees on having and affording external support, partnerships with local entrepreneurs and/or NGOs could promote a more effective services provision (for operation and maintenance tasks). Additionally, the Health Center plays an important role by educating and training people towards enhacing knowledge on water, health, sanitation and hygiene. Finally, this thesis finds that as NGOs have a rich knowledge and practical experience working with communities, they are important actors with the potential of working as supporters and facilitators on educational programs and within water services provision.

The actual interest and acceptation shown by Cuncani's members on a simple and chemical-free technology, contextualization and the understanding of community's needs, preferences and cultural beliefs, are among the main drivers this thesis finds that could enhance and promote the implementation of the D4field. In relation to the long-term sustainability, education was defined as crucial to increase awareness among people (including the JASS members) in terms of health and water quality, to instill a payment culture and to strenghthen the sense of ownership. On the other hand, clear and enforced participatory frameworks are key on enhancing entrepreneurial participation; communication and coordination among actors involved in services provision and an effective and efficient combination of top-down and bottom-up approaches are crucial towards the sustainability of services.

Improvements on health, people's productivity, community development and growth, reduction in health expenditure from communities and public authorities, improvements on coordination and communication among institutions; are identified by the present thesis as key elements that the implemention of the D4field or a water-related technology will improve. Finally, this thesis emphasizes that the achievement of a safe and sustainable water supply in any community without proper hygiene practices will undermine the level of health benefits that communities would reach. Therefore, authorities and organizations play a crucial role in promoting the required training and education among communities to boost their health improvements and the consequent increase in productivity, development and growth.

Finally, this thesis suggests that given the high level of trust that communities have in NGOs and their rich knowledge and practical experience, a convenient strategy to start deploying markets for Watersprint AB would be to create partnerships with these organizations. Furthermore, NGOs have a strong potential role as drivers for the implementation of water-related technologies and to increase effectiveness of public institutions in relation to services provison. On the other hand, the author suggests that public authorities have a quite strong reason to improve their current water purification systems; not only they are not culturally accepted by some communities but have not delivered the required results in terms of health benefits, and as this thesis proves, community members are suffering from illnesses that might be related to poor water quality. Finally, in relation to water governance frameworks, if a holistic approach is to be the baseline to develop them, the author suggests to focus future research on defining and clarifying how the most effective participation approach could work in terms of involving the private sector and local entrepreneurs within water services provision.

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List of Abbreviations

BWM	Better Water Maker
DIRESA	*Dirección Regional de Salud* [Regional Health Direction]
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EQB	Environmental Quality Board

GWP	Global Water Partnership
IADF	Institutional Analysis and Development Framework
IMTA	*Instituto Mexicano de Tecnologías de Agua*
INEI	*Instituto Nacional de Estadísticas e Información* [National Institute of Statistics and information]
IRENA	International Renewable Energy Agency
IWRM	Integrated Water Resources Management
IRC	International Water and Sanitation Center
JASS	*Juntas Administradoras de Servicios de Saneamiento* [Community Water Management Boards]
MDG	Millennium Development Goals
MINSA	*Ministerio de Salud* [Ministry of Health]
NGO	Non-governmental Organization
OECD	Organization for Economic Co-operation and Development
O&M	Operation and Maintenance
PPP	Public-Private Partnership
SANBASUR	*Saneamiento Ambiental Básico Rural* [Basic Rural Sanitation]
UV	UltraViolet
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
WHO	World Health Organization

1 Introduction

1.1 Background

Water is fundamental for life. However, the complexity and challenges behind access to clean and safe water supports the need of testing new solutions towards achieving the sustainability of water services in the developing world. Considering that water governance and sustainable water resources management is the baseline and the starting point towards achieving sustainable access to safe water, the first element that is required to be properly defined is the concept of water governance. Among the vast range of definitions that can be found regarding water governance, the Global Water Partnership (GWP) (2002) defines it as "the range of political, social and economic systems in place to develop and manage water resources (and the delivery of water services) at different levels of society" (p.14). Furthermore, Franks and Cleaver (2007) define it as "the system of actors, resources, mechanisms and processes which mediate society's access to water" (p.26). Therefore, from the different definitions of water governance some key elements can be identified in order to promote the efficient and sustainable management of water resources and the consequent provision of water services.

Furthermore, when referring to water services, the World Health Organization (WHO) and the IRC International Water and Sanitation Center (2003) define the main characteristics of a "sustainable" service; a service is sustainable if it works properly and it is used by the users, if it delivers the proper amount and quality of water, if it provides both health and economic benefits, if it works for the proper amount of time, if it involves to the community when managing the service, if maintenance costs are covered by local fees and if it does not promote any harmful to the environment (p.2). Moreover, when it comes to health and economic benefits from safe drinking water services, Hutton and Haller (2004) estimated that all water and sanitation improvements can be considered as cost-beneficial at a worldwide level; even in the most pessimistic scenarios, when including all possible benefits coming from improved water and sanitation services, the potential economic benefits generally offset the costs (Hutton & Haller, 2004).

As improved water services and sustainable management of water resources continue to be a quite relevant study area, technological innovation can serve as a mean towards the achievement and provision of safe and sustainable water services for the worldwide population (WHO & IRC, 2003). The present research work contributes to these means by providing practical knowledge on the possible implementation and maintenance of an alternative water sanitation technology in a rural community from Peru. In the present sub-section, Peruvian legislation for the provision of water services will be introduced together with the case study of Cuncani and finally, the D4field as water solution will be presented.

1.1.1 Peruvian legislation for the provision of water services

As for the present thesis work a Peruvian rural community was selected to develop a case study, a general overview of the Peruvian context when it comes to legislation for the provision of water services is required.

Generally speaking, as Peru was established as a decentralized State, this country has three main levels regarding territorial and responsibility's divisions; in this regard National, Regional

and Municipal governments are established. According to *Defensoría del Pueblo*[1] (2008), although each of these governmental levels has its specific responsibilities, they all shall coordinate actions in an integrated manner considering the principles defined in the National Constitution.

On the other hand, when it comes to sanitation and the provision of water services, according to the *Defensoría del Pueblo* (2007) since the Constitution of 1979, local governments or Municipalities were acknowledged as the responsible for the provision of basic services such as water and sanitation; however, the National government is responsible for providing the legal framework in which both Regional and Local governments can develop their functions. Moreover, acknowledging the possible lack of capacities, financial and human resources within Municipalities, it is established that in case that a Municipality is not able to effectively comply with its responsibilities, the Regional government shall provide the required support in order to guarantee the services provision for every community. Furthermore, it is important to highlight that in order to improve the effectiveness on the provision of basic services; in 2004 the Water and Basic Sanitation Offices were installed in each Municipality (*Saneamiento Ambiental Basico Rural* [SANBASUR], 2007).

Additionally, as reported by the SANBASUR (2007), with the intention of guaranteeing the sustainable provision of water and sanitation services and considering the fact that communities are the ones demanding for services, therefore communities should be directly involved in the management of its own services. In this regard, the *Juntas Administratdoras de Servicios de Saneamiento* (JASS) or Water and Sanitation Management Boards are established within the community-based principle in order to promote the effectiveness and sustainability on the provision of basic services (SANBASUR, 2007).

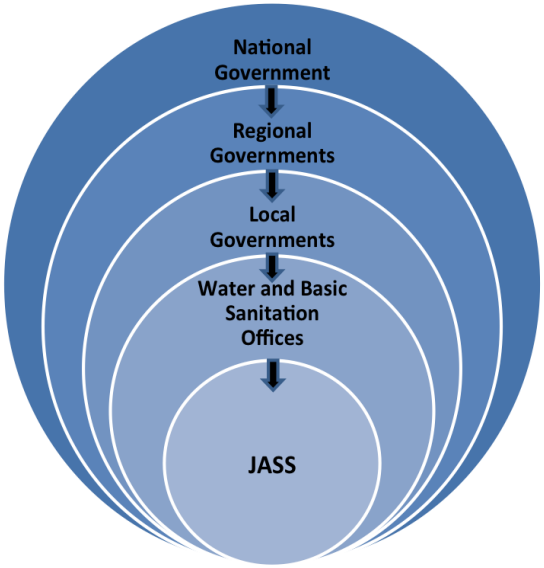

Figure 1 Peruvian responsibility levels within water and sanitation services provision

Main responsibilities of the JASS in each community are to manage and operate water and sanitation services, to develop an annual work plan with the corresponding required budget, to establish and charge the payable fee by each family, to safeguard the community's infrastructure for the provision of basic services, and to represent the community and promote effective communication with the Water and Basic Sanitation Office from the correspondent Municipality (SANBASUR, 2008). The different governmental levels involved in the provision of water and sanitation services in Peru are illustrated in Figure 1.

[1]*Defensoría del Pueblo* or Ombudsman from Peru is defined as the governmental institution in charge of advocating for human rights, to supervise compliance of the State duties and to monitor the effective public services provision in the whole national territory. (http://www.defensoria.gob.pe/defensoria.php)

1.1.2 Case-study: Cuncani

In order to further the understanding on the information and problem definition that will be later presented, socio-demographic, economic and cultural aspects of the selected community for the case-study development will be introduced.

According to Nexos Comunitarios (2012), Cuncani is a high Andean and rural community located in the Cusco Region and within the District of Urubamba; therefore under the responsibility of the Municipality of Urubamba. Regarding spatial distribution of households, due to the lack of planning when developing and constructing the different households, Cuncani is organized from a semi-nucleated to a disperse manner. As reported by the community's president, Cuncani has 74 households with an approximate of 300 members in total (G. Merma, personal communication, February 6, 2015). By 2012, the average number of family members was five, the average age of Cuncani's members was 37.96 years and the average number of children per family was 3.03 (Nexos Comunitarios, 2012).

On the other hand, Cuncani's main economic activities are related to animals grazing (mainly llama, alpaca and sheep) and to agriculture activities that are done with the intention of sustain themselves from their own production. Additionally, as commercial and/or touristic activities are not given in a constant basis, most community members cannot rely on direct financial resources but basically subsist from their own agricultural and animals grazing activities (Nexos Comunitarios, 2012). Furthermore, according to Nexos Comunitarios (2012) Cuncani has more than 93% of its population living in poverty and 68% living in extreme poverty conditions. In addition to this, only approximately half of the community has access to electricity and yet, this service is quite unstable and not reliable. Finally, some community members own communication devices such as cell phones; however, as Cuncani itself does not have phone reception, members have to reach the closest town in Lares to be able to communicate (G. Merma, personal communication, February 6, 2015).

Figure 2 Cuncani (Source: Author)

Regarding water services provision in Cuncani, according to E. Rodríguez, personal communication (February 11, 2015) there is water infrastructure for both water access and purification. In this regard, chlorination is the current purification method used in all rural communities under the responsibility of the Municipality of Urubamba. Furthermore, E. Rodríguez, personal communication (February 11, 2015) highlights that the operation and management of water services should be carried out by the JASS from Cuncani. However, Nexos Comunitarios (2012) highlights that water is not being properly purified and as a consequence of this, most children from Cuncani are suffering from stomach diseases related to parasites due to poor water quality.

1.1.3 An Innovative Water Solution: the D4field

Effectiveness of UltraViolet (UV) light has been proven in terms of water disinfection from pathogens such as bacteria, parasites, viruses and protozoa (Clarke, 2011; United States Environmental Protection Agency [EPA], 1999; and Wagenet et al., 2004). However, conventional UV light treatment systems have shown a number of limitations that require improvements and innovation in the field. According to Schowalter (2008), systems based on UV radiation are based on mercury lamps that are bulky and they normally heat up the water that is disinfected. When it comes to operational aspects, conventional systems need to be permanently active if water is to be effectively disinfected, warm-up times can be of several minutes and the average lifetime of a mercury lamp is one year (Crystal IS, 2014; and Schowalter, 2008). Furthermore, according to Clarke (2011), mercury UV lamps have the risk of breakage with the consequent potential mercury release, promoting strong concerns about potential health risks from mercury exposure. In addition, from the environmental perspective, Schowalter (2008) highlights a concerning fact on the disposal of mercury lamps; if not properly controlled, it can generate accumulation of mercury in landfills and/or the release of mercury vapor into the atmosphere.

Aiming to overcome the challenges of conventional UV lamps, LEDs have shown a great potential to improve cost-efficiency, effectiveness, safety and simplicity from conventional UV light water treatment systems. In this sense, due to the switchable characteristic of LEDs, these can be synchronized with the water flow thus promoting a longer lifetime and energy savings. Finally, besides being mercury-free, LEDs radiate a minimal amount of heat and warm up instantaneously (Crystal IS, 2014; and Schowalter, 2008).

Towards the required innovation for water purification alternatives, Watersprint AB has developed in Sweden a water purifying technology called the D4field. Through the use of UV light, this technology aims to remove all pathogens that could be present in water and that could directly affect human health. This technology can produce 15 L/min of clean water with an electrical consumption of only 7 Watts and has a 3-year guarantee of no maintenance required while being in normal operation (K. Persson, personal communication, December 19, 2014).

Figure 3 D4field (Source: Watersprint AB, 2014)

Besides the benefits of water disinfection effectiveness from UV light, there are two elements that make the D4field such an innovative water purifying technology; first, it is an efficient nano-based LED device and second, as reliable electricity access continues to be an important issue especially in rural areas of developing countries (International Renewable Energy Agency [IRENA], 2012), the D4field has integrated solar panels in order to meet its electrical requirements (K. Persson, personal communication, December 19, 2014). As safe and clean water is produced through the use of a renewable energy source in a simple purification device, the D4field can be placed as part of the clean-tech innovations that aim not only to be effective in meeting people's needs but also efficient in terms of contributing with environmental sustainability (Johansson et al., 2003).

1.2 Problem Definition

Although Latin America and the Caribbean have a quite rich variety of biodiversity and natural resources such as water, the World Bank (2011) estimates that approximately 20% out of the 120 million people that live in rural communities still lack access to an improved drinking water supply. In 2011, the United Nations (UN) declared water as a human right and furthermore, the United Nations Development Program (UNDP, 2004) states that access to clean water is vital to human health and survival; therefore it is considered as a key element for the improvement of life quality and as a mean towards poverty alleviation (UDNP, 2004).

On the other hand, in spite of the many initiatives from national governments, non-governmental organizations (NGOs) and different organizations to contribute to the sustainable management of water resources together with the provision of access to clean water in Latin America, Akhmouch (2012) highlights that these initiatives have been very fragmented and not context-specific. Therefore, access to improved water services continues to be a key issue and a challenge in which more research needs to be developed (Akhmouch, 2012).

Along with development and poverty alleviation, health is one of the elements that is directly affected by water consumption; poor water sanitation can promote waterborne diseases due to the presence of pathogens such as protozoa, parasites, viruses and bacteria. Moreover, poor water sanitation can deliver serious health consequences (being diarrheal diseases the most common ones) that affect the most vulnerable people, which are mostly children and elderly from developing countries (WHO & IRC, 2003); according to the WHO (2007), 1.8 million people die every year due to diarrheal diseases and most of these deaths are from children under 5 years old. On the other hand, the WHO (2007) estimates that from the worldwide deaths caused by diarrheal diseases, 94% of them could be prevented through the increase of availability of clean water, improved sanitation and hygiene.

Acknowledging the importance of having access to safe water, the UN established the Goal of ensuring Environmental Sustainability within the Millennium Development Goals (MDGs). Furthermore, within this goal, one of the targets was defined as "halving, by 2015, the proportion of people without sustainable access to safe drinking water" (UN, 2014, p.43). Moreover, the UNDP (2004) recognizes the interrelation among the achievement of different goals through the improvement of access to safe drinking water; for example, improving health through safe water consumption can also promote the eradication of extreme poverty and hunger and, as previously mentioned, can also promote the reduction of child mortality.

Regarding the MDGs and the specific target previously mentioned the UN (2014) states that the sustainable and safe drinking water access target was met in 2012 at a worldwide level. Despite this achievement, when it comes to Latin America and the Caribbean there are countries which still have not met the established water access levels. In this regard, the lowest levels of water access coverage are found in Dominican Republic, Ecuador, Haiti, Nicaragua and Peru (WHO & United Nations Children's Fund [UNICEF], 2014). In the case of Peru, the WHO & UNICEF (2014) indicates that by 2012 this country had a total coverage of improved drinking water supply of 87% and moreover, a rural coverage of 72%. Therefore, these numbers place Peru in the track of achieving the target within the MDG but still needs some efforts to reach the required level of sustainable and safe water access especially for rural areas (WHO & UNICEF, 2014).

The previously mentioned D4field technology has a high potential to contribute with the achievement of access to clean and safe drinking water in the developing world. However, despite its potential, technical characteristics of a particular purifying device that could meet

people's water needs are not necessarily enough to be successful. Furthermore, according to Johnson et al (2006), social, economical, political, cultural and technical elements must be considered in every different community if sustainability of water services is to be achieved. Another fundamental study element for every different rural community is the ideal scheme in which the different actors should be involved and participate in the process of implementing and maintaining in time a particular technology (WHO & IRC, 2003). Moreover, as these rural communities are populated with people who are mostly unable to fulfill their basic needs not only in food and education but also in water and sanitation, the complexity of the issue of promoting sustainable and safe water services goes beyond the simple implementation of any technology (Johnson et al., 2006). In this regard, the WHO and IRC (2003) state that a major concern is to find the technological and institutional alternatives in which users will be willing to pay together with the achievement of health and environmental sustainability.

1.3 Research Questions and Objectives

Given the fact that rural communities are the most vulnerable in developing countries and in the interest of enhancing knowledge regarding access to improved water services in one of the countries with the lowest safe and sustainable water access in Latin America and the Caribbean, the present research work has as main objective to assess the factors influencing the deployment of a water purification solution in a rural community. This research also aims to enhance the understanding and provide practical knowledge around the key elements related to the sustainability of water services and technological implementation through the development of a case study in a rural community from a developing country.

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   - ✓ Which are the institutional and social structures, in terms of responsibilities and costs sharing, that can support not only the implementation but also the maintenance and long-term sustainability of the technology?
   - ✓ Which are the main drivers that can enhance both the implementation and long-term sustainability of the technology in Cuncani?
   - ✓ What are the key parameters that the technology will improve in Cuncani's members and in public institutions and organizations?

Along with the objectives previously mentioned, the present research work will be developed within the Peruvian rural community of Cuncani under the collaboration with Watersprint AB (as manufacturer and distributor of the D4field technology) and with the Peruvian Non-Governmental Organization (NGO) Nexos Comunitarios, which currently works towards human development initiatives and has already started to work in different projects within Cuncani. Therefore, the contribution of Nexos Comunitarios will be vital in terms of providing previous knowledge about Cuncani in order to set the starting point for the present research and the related field work.

1.4 Scope and Limitations

As stated previously, a rural community of a developing country was selected to perform the present research. In this regard, Cuncani was selected as case study from Peru due to different reasons; first of all, it complies with the definition from the *Instituto Nacional de Estadísticas e Información* (INEI) or National Statistics and Information Centre in Peru of a rural community[2]. Essentially, this community is facing the same challenges that most rural communities in the Cusco Region normally cope with; in terms of poverty, sustainable access to basic services such as water and electricity, and tough living conditions including weather, among others (Nexos Comunitarios, 2012).

On the other hand, Cuncani has already a water access system for the catchment and distribution of water into every household of its community members; this will also promote a smoother process in the implementation of any water-related technology in terms of having available a certain water infrastructure. However, it is important to highlight the fact that in the present work no studies will be made in terms of determining the current state of neither the water infrastructure nor the water quality provided for the community of Cuncani. Any information presented in this regard will be based on the data available from different sources including interviews with relevant actors involved in the provision of water and health services for Cuncani's members.

As chlorination is the current method that was implemented by the Municipality of Urubamba in order to purify the water in Cuncani, the present thesis assumes that this local government already identified a water quality issue that is to be tackled. Therefore, the hypothetical implementation of the D4field technology will be considered as a possible replacement for the current purification method of chlorination.

Given the established time to develop this research and the number of objectives to be achieved, a community with previous studies already done was another element to consider when selecting Cuncani. Basically, having the collaboration with Nexos Comunitarios will promote a step further into the data gathering for the present research. In this regard, information related to geographic and demographic characteristics, main economic activities developed by its community members and the related average income, the current state on their health, among others, was already gathered by this NGO in previous surveys.

In spite of the fact of having the information gathered by Nexos Comunitarios regarding Cuncani itself, limitations on the availability of other general information and more specific data coming from the public authorities can represent an important issue for this research. For example, data coming from the Municipality regarding expenditures on the operation and maintenance of the current water system in Cuncani, data coming from the Health Center regarding expenditures related to water-related diseases and the average number of people suffering from these diseases in Cuncani, data coming from the Ministry of Health related to water characteristics and water quality in Cuncani, among others, are important data that could enhance the findings of the present research and that are only managed by these authorities. When referring to limitations in this sense, the present work is relating them not only with the actual availability of the data (in terms of having collected the data for the particular rural community of Cuncani) and also to the possible lack of willingness from public authorities to provide this data for external researches.

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[2] The *Instituto Nacional de Estadísticas e Información* (INEI) or National Statistics and Information Centre in Peru defines as rural area as one that has no more than 100 houses grouped contiguously and/or is not a capital from a district. Furthermore, if it has more than 100 houses, these are scattered without forming blocks or cores (http://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib0014/varicont.htm)

Moreover, regarding the activities related with the methodology for the data gathering of this research, limitations can be expected in terms of having lack of willingness from the public authorities and/or different organizations to participate in interviews and the focus group activity that is to be carried on.

Furthermore, when carrying on the survey directly in the community, two important limitations can be expected; first of all, the lack of willingness of people to agree to participate in a face-to-face survey and finally, to respond to all the established questions with the most accurate, detailed and realistic answers. Additionally, another important limitation is regarding language; although Spanish is the official language in Peru and it is the one spoken by people from public authorities, private companies and different organizations, most members from rural communities speak Quechua. Therefore, as a translator will be needed to carry on the survey in Cuncani, important information can get lost in the translation process and furthermore, the translator itself can provide a bias element when doing the interviews and then providing the answers that are to be gathered.

In terms of generalizability, it is important to highlight that a single community was chosen in order to provide a more specific and accurate case study for the role of the D4efield technology and related water services. Therefore, considering the fact that every community is different from particular perspectives (socially, culturally, economically and politically diverse), this research is not intended to be directly generalizable to other communities different from Cuncani. In spite of this fact, as relevant information from different actors will be gathered during the present research, some of the outcomes can be possibly generalizable to other communities under the responsibility of the public authorities which will be interviewed during this work; for example to the communities besides Cuncani that are under the political jurisdiction of the Municipality and of the Health Center in charge of managing Cuncani's patients.

Although the outcomes of the present research are not directly generalizable, if Watersprint AB is to continue with the implementation of the D4field technology in other communities from developing countries, key learning lessons from the this work can serve as a baseline for future research. Furthermore, key learning outcomes can be considered as baseline information not only for the D4field particular technology but also for the general implementation and maintenance of other water-related technologies in rural communities.

1.5 Audience

Given the variety of elements that are to be covered in the present research project within a technological implementation process with the correspondent actors involved, the outcomes of this work can be quite useful for different societal actors. Considering that a set of key elements will be given for the technological implementation and sustainability in rural areas, these elements can be of practical and convenient use for actors such as:

- ✓ Entrepreneurs and Private Businesses: aiming at the development and deployment of technologies targeted for rural communities. In this sense, as the D4field technology will be directly involved during this work, the first beneficiary of this research will be Watersprint AB.
- ✓ Public Authorities: Municipalities and Health-related institutions aiming at improving water management systems and in doing research with different communities.
- ✓ Non-governmental Organizations: working with water and technology-related projects.

- ✓ Researchers: investigating elements related to water governance and water resources management, technological innovation, implementation and sustainability; drivers and barriers for these.

1.6 Thesis Disposition

In order to enhance the understanding of the reader, the present thesis work will be presented in the following outline:

Chapter 1 (Introduction) introduces the background and the focus problem that is to be addressed in this research, it presents the main objectives and research questions that will be answered, states the scope for this research work and also the possible limitations during the development of this project; later, it suggests the possible audience for who this work can be of practical knowledge and finally, the thesis disposition will be presented.

Chapter 2 (Research methodology) introduces the research approach and structure, the case-study selection and justification will be provided, the methods used for data gathering will be presented and finally, data-analysis methods will also be introduced.

Chapter 3 (Water Governance in Latin America) first introduces the different concepts of water governance and main aspects of water governance in Latin America. Finally, it presents diverse analytical frameworks for water management in order to identify key elements that are to be considered within sustainable management of water resources and to develop an analytical framework to be used in Cuncani's context.

Chapter 4 (Water Solutions in Practice) overviews the different elements that need to be considered in order to foster sustainability when implementing, operating and maintaining a technology in a community.

Chapter 5 (Findings) presents the findings of the present research; main outcomes of the different interviews, results from the survey in Cuncani and main outcomes of the focus group activity.

Chapter 6 (Analysis and Discussion) discusses and reflects on the findings based on the analytical frameworks established within Chapters 3 and 4.

Chapter 7 (Conclusions and Recommendations) summarises the main findings and lessons learned during this research together with the main contributions, provides recommendations for the relevant audience of this research and deliver suggestions for further research.

2 Research Methodology

In the current chapter, the research methodology used within this research will be presented; the research approach and structure will be explained in order to enhance the reader's understanding on the methods that were used. Later, the rural community that was selected to develop the case study for the present research will be justified. Finally, the different methods for data collection and analysis will be introduced.

2.1 Research Approach and Structure

Although this thesis can be considered as a qualitative research, given the nature, complexity and scope that were to be covered, both qualitative and quantitative methods were used during the research work. Based on the triangulation principle, four main stages and related data-gathering methods were used in order to reach a more comprehensive level of understanding, reduce bias on the information and to provide a better overview of the different angles of water management issues and the drinking water supply within Cuncani. As stated by Yeasmin and Rahman (2012), triangulation not only enhances the validation of the results within a research, but it is also a mean towards deepening and widening the understanding about a certain social phenomena. The stages and activities are illustrated in Figure 4:

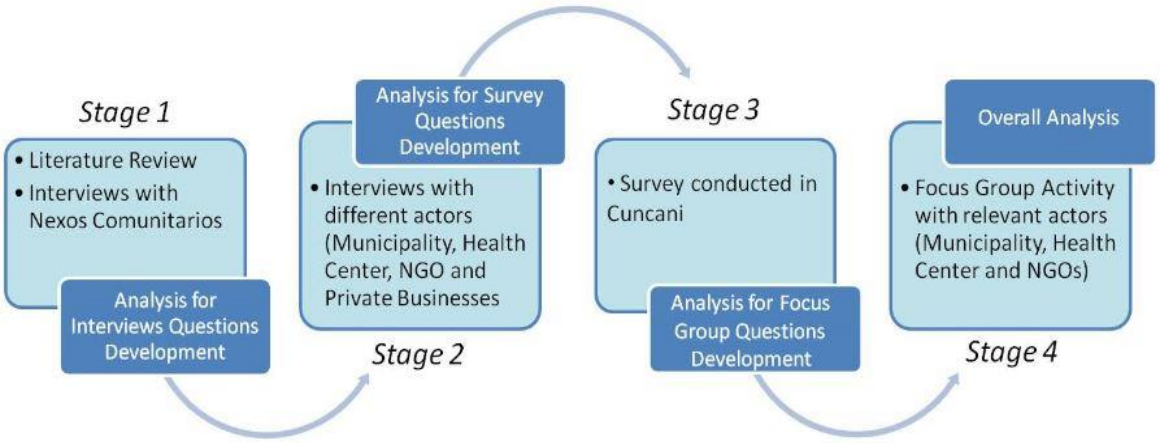

Figure 4 Methodology and research structure

During the first stage a literature review was carried on; in this part the focus was to go through the previous studies, surveys, interviews and focus groups that were carried on in 2013 by the NGO Nexos Comunitarios. Furthermore, general information about Cuncani with its community members and different characteristics were reviewed in order to obtain a general overview of the context in which the research was going to be developed and to identify the actors that needed to be considered during the present research. Additionally, as daily contact with Nexos Comunitarios personnel was given, discussions and personal interviews were carried on with them to gather their previous experiences with the community, local authorities and other NGOs. After obtaining enough information and data about Cuncani and a general overview of the context and the different actors involved, an analysis to develop the questions used during each of the interviews started.

Afterwards, the second or interviews stage started. For this stage, face-to-face and semi-structured interviews were carried on in order to obtain a deeper understanding on the daily

work that is developed by the different actors when it comes to water-related projects. Relevant actors currently involved (directly or indirectly) with the provision of drinking water services in different rural communities (including Cuncani) were interviewed. From the information gathered during this stage, an analysis was carried on to develop the questions for the survey developed in the third stage.

Later, a survey within the community was conducted during the third stage. For this, a face-to-face structured survey was designed in order to obtain data and general information about water-related and health issues from a determined percentage of the community's households. After finishing the third stage, an analysis of the data gathered was done together with the previous analysis on the different actor's comments in order to develop the questions for the focus group activity that was carried on in the fourth stage.

Finally, during the fourth stage the focus group activity was conducted with the aim to gather different opinions and thoughts among the relevant societal actors about the water problematic in Cuncani and furthermore, to define a set of key elements that need to be considered when implementing and maintaining in time a technology in a rural community. Subsequently, after finishing the fourth stage and having gathered most of the relevant and required information for the present research work, the overall analysis started.

2.2 Case-Study Selection and Justification

Given the complexity that can represent to implement a new technology in a rural community in terms of the many different elements that can affect the possible results and the many societal actors involved within this process, the selection of a fair small rural community was considered the most suitable alternative to develop the present thesis work. As stated previously, different elements promoted the selection of Cuncani as a suitable case study for the feasibility study for implementing the D4field technology. The first element was the fact that is a rural community from a developing country and there were previous studies available related to this community; this made the research process much more straightforward in terms of having a starting point.

On the other hand, although this community already has a water access system for the catchment and distribution of water into every household of its community members, according to Nexos Comunitarios (2012) this community currently has water-related issues in terms of having low-quality in their drinking water supply, which have caused different health issues among its members. Therefore, the first step towards identifying a water-related problem was made and furthermore, Cuncani will be even more suitable for a study in order to promote a future intervention towards the achievement of the required drinking water quality standards.

Additionally, in terms of economic aspects, as previously stated Cuncani is a rural community with a 93% living in poverty levels and 68% living in extreme poverty levels (Nexos Comunitarios, 2012). This fact can represent a challenge for the implementation of any technology (not necessarily water-related) and therefore, by considering a community living under these conditions the study will be basically done for the 'worst-case scenario' and future research on communities with better economic conditions might be more straightforward.

2.3 Methods for Data Collection

2.3.1 Literature Review

The literature review represented the first step into the information and data-gathering process; in this case a first review into the different analytical frameworks applied for sustainable water resources management was carried on. Later, for the fieldwork itself, general information and data about Cuncani was gathered based on previous surveys, interviews and focus groups activities that were developed by Nexos Comunitarios. This step provided a baseline on the contextualization for the development of the present research work. Additionally, a review on the political structure of Peru was conducted in order to identify and obtain general knowledge regarding the territorial division and the correspondent responsibilities of the different government levels. This review was also done in order to identify the relevant actors from the public authorities' perspective who theoretically have responsibilities over water and sanitation services, especially at the local level.

2.3.2 Interviews with Relevant Societal Actors

In order to widen the understanding on the current situation of Cuncani and its drinking water supply and also in an attempt of identifying the causes of the current water-related problems in Cuncani; after identifying the relevant actors who are theoretically and legally involved in the provision of water services, face-to-face semi-structured interviews were conducted. It is important to highlight that for every interview a different range of questions were developed; even for the same working field of the actors, depending on the very specific activities they developed and the focus the actor has, questions were directed to obtain specific information; from 7 to 9 questions were developed and administered for each of the interviews.

A total of 5 interviews were carried on in this sense; to better define the current state on the water infrastructure and purification methods used, one interview with the representative of the Water and Basic Sanitation Office from the Municipality of Urubamba (legally in charge of the water infrastructure in Cuncani) was conducted. Later, in order to further the understanding and validate the data available on health issues, one interview was conducted with a representative from the Lares Health Center (in charge of providing health services to Cuncani's community members due to the fact that is the closest health center to this community). Afterwards, in order to enhance understanding from different perspectives besides the public sector, two interviews with private businesses that currently work with rural communities were conducted, the owners of HARBEC Plastics and Buen Power Company were interviewed; the first company has a water-related technology and have even worked with Cuncani, the second company is in the energy sector but have a wide experience working with different rural communities in Peru. Finally, an interview with an NGO was conducted due to the fact that it currently works directly with the provision of a water-related technology and has also health programs within rural communities; therefore, this organization provided important inputs regarding the implementation and maintenance of a technology within the context of a rural community.

2.3.3 Survey in the Community (Cuncani)

With the aim of deepen the understanding on water and health-related issues within Cuncani, the development of a survey directly into the community was of great importance for the present research work. Considering the fact that Cuncani has 74 households (G. Merma, personal communication, February 6, 2015) thus, based on the different perspectives regarding the most convenient sample size for a survey within a qualitative study (Marshall et

al., 2013; Johnson & Onwuegbuzie, 2012; Castellan, 2010; Creswell, 2003), in an attempt to gather quality of over quantity of the information, a sample of 50% of the total households was selected to develop the survey and 37 surveys were carried on in Cuncani.

A face-to-face structured survey was conducted in each of the 37 households with a total of 19 questions per survey; each survey had three sub-sections (Section A: General water issues and health; Section B: Technology-related issues; and Section C: JASS (Water Management Boards from the Communities) and water management issues). Therefore, the aim of this survey was to obtain directly from the community members information about their water-related health issues, perceptions on the relationship between water quality and health, perceptions on the importance of purifying their drinking water, health-related expenditures, length of their water-related diseases and the time affectations on their daily activities such as working and studying. Furthermore, in Section B of the survey the prototype of the D4field was showed and explained to each of the interviewed families in order to perceive their first opinion on a purifying device like this and furthermore, if would they prefer the UV-light purification method over chlorination. Finally, for Section C the aim was to obtain their perspective on the performance of the JASS or water management boards on the water-related issues and the improvement opportunities the community suggests for them.

As in these types of communities the role of women and men tend to be different from each other, considering the different opinions and responses that could possibly be given between the different genders, for this thesis work an almost equal amount of women versus men interviewed was attempted in order to widen gender perspectives; a total of 51.3% of men a total 48.7% woman were interviewed. On the other hand, an enrichment element which was of great importance for the present thesis experience was opportunity to actually remain in the community during the time while the survey was being developed; in this sense, personal observations, although fair subjective, can add a wider perspective and understanding on the living-style of Cuncani's members. Understanding their daily activities such as working, cooking, hygienic practices, among others, is an important element in order to also perceive their cultural aspects.

2.3.4 Focus Group Activity

As pointed out by Larson et al. (2004), the focus group method can produce high quality data that can make more effective the decision-making process in any situation; therefore, this method was selected by the present thesis work in order to deepen the data gathering and enhance triangulation. The main goal of this activity was to identify agreement and/or disagreement points among different actors regarding which are the causes of the drinking water issues in Cuncani and on how the quality of the drinking water supply in Cuncani can be improved through the sustainable implementation of a technology like the D4field.

This focus group is to be of great contribution to the present research given the fact that different perspectives were considered when trying to reach a certain level of understating; as suggested by Larson et al (2004) and Cronin (2011) a total of seven questions were developed (to be in the ideal range of less than 10 questions) and a total of seven participants attended also in order to comply with the ideal number of participants for a focus group activity (from six to ten). Participants of this activity included a representative from the Health Center that treats Cuncani's patients, a representative from the Basic Sanitation and Water Office within the Municipality, a representative from the Regional Direction of the Ministry of Health (DIRESA), a representative from Cuncani, a representative from three different NGOs working with different projects in rural communities in the Cusco Region.

It is important to highlight that this activity was carried on after finishing the personal-interviews phase and the survey in the community, given the fact that it was necessary to first achieve a general understanding and overview on how the different actors work when managing water issues, generally speaking and also directly in Cuncani. Moreover, it was also of great importance to first determine if a technology like the D4field could possibly be accepted by the community, if for example it could be culturally accepted by them; this as a starting point to then determine how a particular technology could be implemented and then maintained in time and furthermore, to understand which actors should be involved in these processes and how would be the responsibilities allocation among them.

Additionally, as for this activity there were no 'correct' or 'incorrect' comments, the interesting elements to evaluate were each of the suggestions made by different actors and moreover, the interaction and dynamics among the different societal levels. Additionally, it is to be of great importance to identify the possible 'leader' or the institution to which people can have more trust on and can serve as a possible manager when carrying on any water-related projects.

2.4 Methods for Data Analysis

Given the fact that the water governance field does not have a specific framework that can be universally applied under any circumstances and context; based on the different analytical frameworks that were reviewed on this research work and within sustainable water resources management principles (Integrated Water Resources Management Approach, the Demand-based Approach, the Multi-level Approach, the Sustainable Management for Common-pool resources Approach, and the Water Governance and Poverty Approach) key elements were identified. Later, from the available literature regarding technological innovation, sustainable implementation and maintenance in rural communities, key elements were again identified. After having key elements from both sustainable water management and technological innovation and implementation, these were combined in order to analyse the findings of the present thesis work.

Having in consideration the research questions that are to be answered, based on the developed framework, key problematic elements for the provision of safe drinking water in Cuncani were identified as a starting point based on the information gathered from the four stages of the present methodology (literature review, interviews, the survey and focus group activity). In this sense, the diverse perspectives and comments from each relevant actor were grouped in order to be compared with the theoretical framework that defines how water issues are to be managed when providing services to rural communities. It is important to highlight that the different perspectives were analysed based on both the developed framework and also with Peruvian legislation, given the fact that this is the national theoretical framework that should have been applied; with the last comparison, implementation gaps could possibly be identified.

Finally, the answer to the second research question had a stronger focal point on the outcomes of the focus group. However, two methods were used in order to answer this question. Firstly, from the theoretical framework developed and according to what the Peruvian legislation establishes, a possible theoretical scheme of implementation and maintenance for the D4field was developed before carrying out the focus group activity. Later, the theoretical scheme was validated after having the outcomes from the focus group discussion. In this sense, the theoretical scenario could be compared with the practical scenario that was established by the different actors' perspectives and previous experiences working with rural communities.

3 A Conceptual Framework for Water Governance in Cuncani

Considering the fact that sustainable water management towards the achievement of access to improved water services was acknowledged as a fundamental element for poverty alleviation, water governance has become an important study element for policy making and implementation. One of the first issues found during the present literature review were the different definitions developed for water governance. For example, the Global Water Partnership (GWP) (2002) defines it as "the range of political, social and economic systems in place to develop and manage water resources (and the delivery of water services) at different levels of society" (p.14). Furthermore, referring more to the interactions within the elements of a system, Franks and Cleaver (2007) define it as "the system of actors, resources, mechanisms and processes which mediate society's access to water" (p.26). Moreover UNDP (2004) establishes the key elements and challenges towards successful water governance and additionally relates effective water governance with poverty alleviation; it states that social, economic, ecological and capacity challenges are the base for water resources management towards effective access to clean water and consequently for poverty alleviation. However, from all these approaches to define water governance is possible to identify some key similarities and elements in which the concept of water governance can be built; it is evident that there are fundamental interactions between social, economic, ecological and political elements in terms of achieving successful water resources management and additionally, within all these different levels, interactions between actors or key stakeholders and resources (human, capital and technological) are given through different mechanisms.

On the other hand, it is important to highlight that all of the above mentioned authors agree in different ways on the acknowledgement of the importance of a contextual analysis within policy making and implementation in terms of the achievement of sustainable water resources management. In this regard, Cleaver and Franks (2008) mention that one of the shortcomings of water governance lies on assuming that a 'success story' in a determined context can be directly replicated in a different context. The Latin American context is a quite particular one, according to Carrasco (2011), this region owns a quite important amount of water resources and yet there are still people lacking of access to safe drinking water in many countries. As stated by Carrasco (2011), water-related policy in the past has had a strong focus on the provision of water services in urban areas whereas in rural areas, due to their intrinsic characteristics of isolated geographic location, low economic capabilities to afford water services, among others, have been left behind by public water-related policies.

Considering that water governance is a quite broad and complex field and that there are no universally applicable conceptual frameworks due to the fact that contextualization is the baseline for every water management policy design, for the sake of the present research work and in order to define a conceptual model which can be applied for Cuncani's case-study, different existing analytical frameworks will be reviewed in an attempt to identify key elements and/or principles regarding water resources management and the provision of sustainable water services.

3.1 Integrated Water Resources Management Approach

Based on the degradation of natural resources together with the growing water crisis and all the related illness, hunger and poverty around this, the Integrated Water Resources Management (IWRM) is defined by the UNDP (2004) as an approach that considers the relationship and interactions among natural resources systems, biological processes, social and

economical systems towards the integration of all these elements in order to achieve an effective management of water resources. Furthermore, it highlights the current need of balancing all natural processes and ecosystems with social, economic and environmental needs and objectives. Moreover, the IWRM is defined as a cross-sectoral policy approach in response to the growing demand for water in the context of finite supply.

Under this approach, the UNDP (2004) also emphasizes the importance of promoting popular participation in the decision-making for designing water and sanitation systems. Considering the recognition of the linkages between environmental health, sustainability, women empowerment and general human well being, the UNDP (2004) defines the key principles of the IWRM approach with the following elements:

- Water should be considered as an economic, social and environmental good.
- Water policies should focus on managing not only in the supply side but also on the demand side.
- Governments should also focus on developing regulatory frameworks towards the effective management of water resources.
- Water resources should be managed at the lowest level required (community level and not only at a national level).
- The importance of gender equity considerations and therefore having women playing a fundamental role on managing and safeguarding water resources with the corresponding empowerment for them (UNDP, 2004).

On the other hand, the UN and Global Water Partnership (GWP) (2007) define the Integrated Water Resources Management approach as a framework to improve cross-sectoral efficiency and cooperation when managing water resources and as a tool towards good water governance. Moreover, it is recognized as a mean towards the achievement of the MDGs and additionally, it acknowledges the link between the directly related water goals with poverty and hunger reduction, the improvement of health, education and to avoid environmental degradation.

Furthermore, in regard of what was established by the UNDP (2004), the UN and Global Water Partnership (2007) also agree with the fact that gender equity and public participation within water resources management is fundamental in order to be effective and sustainable; but it is also added that the IWRM should focus on a better allocation of water resources among different water users and when doing this, is fundamental to have an effective stakeholder's participation and their involvement in the whole decision-making process within water resources management (UN & GWP, 2007). Another important argument regarding the IWRM approach is the fact that this can be easily applicable as a framework for managing water resources, however, it is fundamental to consider the fact that every country and community should establish their own regulatory frameworks and management plans based on the principles provided by the IWRM approach. Furthermore, it is fundamental to acknowledge the responsibility of all stakeholders at every level to design and monitor the status on their water management regulations and programs always considering their local conditions (Rogers & Hall, 2003; and UN & GWP, 2007).

On the other hand, there are some arguments against the effectiveness of the IWRM approach. Cleaver and Franks (2008) mention that although this approach has been applied and due to its attractive concept it is considered as a dominant model for water resources management within policy making, this approach can also promote different things; first, it is

considered as a woolly conceptual model and it is taken for granted that its application can guarantee success (this argument was also emphasized by the Global Solution Networks (2013)); second, it can promote favoring specific technical and managerial fixes regardless the particular context just because previous 'success stories' were accomplished in other different contexts; finally, Cleaver and Franks (2007) highlight that the IWRM approach can be easily used by particular stakeholders groups as a tool (to not say weapon) in favor of their particular interests.

As for the present thesis work, the IWRM approach represents an engaging alternative to use during the analysis of the research findings; it not only covers water governance principles with an holistic approach but also it relates elements such as effective water governance, poverty and the achievement of the MDGs, which are also important elements that are being considered for this research work and furthermore, these elements are directly involved with the context of the case-study that will be developed.

3.2 The Demand-based Approach

The World Bank (2011) points out the Demand-based approach within the Latin American context as a water resources management approach that has been adopted by several Latin American countries for water regulation and particularly for rural drinking water projects. This approach basically focuses on community participation when deciding key elements regarding technology and management systems; within this, communities should participate in the whole project cycle and beyond it, from the planning, execution and operation. The baseline from this approach is the aim of developing water systems that are based on the needs, preferences and willingness to pay from each particular community in order to guarantee the sustainability of any system.

On the other hand, among some of the important elements of the demand-based approach, the World Bank (2011) mentions that this should be able to develop mechanisms to identify the real demand for water services instead of considering misrepresented or conditioned water demands and thus designing water systems in a ineffective manner. Another issue that is pointed out is the need to instill a payment culture among people from the benefited community before implementing any water project in order to improve sustainability of water systems. Additionally, the World Bank (2011) highlights that in order avoid any delays in the provision of water services, after evaluating demand it is also fundamental to evaluate the existing water supply capacity.

Although the demand-based approach can bring several benefits regarding water services supply, the World Bank (2011) also points out some improvement opportunities that should be considered in order to improve the effectiveness of this approach. Among these, strengthening gender participation in decision-making, promoting social conditions to implement and maintain water systems including training and education for every community, also synchronizing time frames to balance these social conditions creation and the infrastructure provision. Finally, promoting public-private social partnerships is also highlighted as an important improvement opportunity due to the fact that communities also need external support to achieve sustainability in their services provision (World Bank, 2011).

As can be seen, from this approach different key elements can be identified; elements such as public participation, gender equity, contextualization of any policy, technical and managerial system and the promotion of public-private partnerships should be considered within policy-making and during all water project cycle and beyond in order to achieve effective water governance. Additionally, as for the case study that will be developed in the present thesis

research, the demand-based approach can represent an interesting analytical framework not only due to the water governance principles that are introduced but also given its applicability and previous experiences in the Latin American context.

Given the fact that this is a quite recent approach that has been applied mostly in Latin America after the Cusco+10 meeting, there is a fair limited literature related to it. As stated by Whittington et al (2008), there is little practical evidence on how the demand-driven approach has worked and if it has been successful after its implementation in different communities. However, as this work was done having in consideration the Latin American and developing countries context, this approach was important to be included. Additionally, within this literature review, only the considered most important source from the World Bank was used to provide the require knowledge regarding the principles from the demand-based approach.

3.3 The Multi-level Approach

Akhmouch (2012) defines the Multi-level approach as a mean to achieve better public governance towards effective implementation of sustainable water policies. Moreover, the Organization for Economic Co-operation and Development (OECD, 2011) states that the water crisis problem is mostly a water governance issue and that there is actually enough water in the world to cope with human and nature needs but this applies only if water is well managed. Additionally, in order to cope with future challenges regarding water, there is need of a more holistic approach which involves the wider perspective and understanding that water issues are not only related to financing and technical drawbacks, but also to communication, education and participation elements (OECD, 2011).

The OECD (2011) establishes that due to every institutional arrangement depends on national elements such as values and heritage; there is need of place-based policies that are adapted to every particular context and integrated to the established institutional setting. It is also assumed that improvements in water governance can be achieved through a more efficient integration of territorial specificities and a better co-ordination between all actors involved and in charge of the design, regulation and implementation of water policies.

On the other hand, considering that water is both a local and global issue, there is also a need to understand that water involves many levels at both territorial and administrative levels with the correspondent involvement of several stakeholders at every single level; furthermore, defining the responsibilities for each stakeholder is another important element for achieving effective water governance. In this regard, the Multi-level approach is defined by the OECD (2011) as a tool used to identify the main problems related to policy-making, coordination between the different levels of a government and moreover, it is defined as "the explicit or implicit sharing of policy making, authority, responsibility, development and implementation at different administrative and territorial levels"(p.18); when referring to different administrative levels is basically across ministries and/or public agencies within both central government and sub-national level; when referring to territorial levels is basically to the different layers at the local, regional, provincial, national and supranational levels (OECD, 2011).

Based on the common pillars used for managing water resources, which are: legitimacy of the governments and institutions involved in water resources management, transparency in the decision-making processes, accountability of all actors involved and the correspondent responsibilities, inclusiveness of all different and relevant stakeholders, fairness in the services supply and in water resources allocation, integration of water policy at all levels, capacity of organizations, institutions and all individuals involved in managing water resources and

adaptability to the changing dynamics of the environment; the OECD (2011) organized the Multi-level approach around seven gaps that are to be tackled within water governance: administrative, information, policy, capacity, funding, objective and accountability. Then, in order to address each of the gaps established, the OECD (2011) establishes recommended actions as the following:

- **Administrative gap**: is given due to the discrepancy between hydrological and administrative boundaries. The suggested action is related to the development of effective policies that reach the appropriate scale and size.

- **Information gap**: is given because of disparities on information's quantity, quality and type between the relevant stakeholders involved in the different phases of water policy development. The recommended action is to develop instruments for revealing and sharing information.

- **Policy gap:** is based on a fragmentation across ministries and agencies involved in water-related activities. The action here is to promote political leadership and commitment among people involved in water resources management and to develop mechanisms based on multidimensional approaches.

- **Capacity gap:** is given due to insufficient knowledge and strategy on scientific, technical and infrastructure fields among actors involved in water-related policies. The recommended action is to develop instruments aiming to build local capacity.

- **Funding gap:** is given due to lacking of sufficient and constant economic resources to implement water policies and especially at sub-national level. The action here is to develop financing mechanisms to support governments at different levels.

- **Objective gap:** this is given basically when actors at different levels establish objectives with no co-ordination between the other actors involved and therefore, the established objectives by a particular actor or governmental agency can overlap or be conflictive with the others established by different actors. The recommended action is to develop instruments to align objectives.

- **Accountability gap:** is related to the transparency of different practices related to water policies due to lack of commitment, awareness and participation. The actions here are related to develop institutional quality instruments that also strengthen the integrity of frameworks at local level and additionally, it is important to enhance participation and citizen's involvement in water-related activities (Akhmouch, 2012; and OECD, 2011).

On the same line of arguments in favor of the Multi-level approach, Gupta and Pahl-Wostl (2013) emphasize the rationale of having water governance responsibilities disperse at different levels up to a local level, stating that in this way is possible to internalize externalities, allowing local heterogeneity, preferences and additionally, it promotes creativity, innovation and experimentation. However, Ostrom (2008) argues that decentralization approaches and local self-organization also require the support of institutional arrangements that are set at other governmental scales such as national. To this, Gupta and Pahl-Wostl (2013) argues that effective water governance should be based on a balance between bottom-up and top-down approaches and between decentralized and cross-level approaches.

Given the attractive scheme in which water governance gaps were introduced by the Multi-level approach and the practical manner in which this tool was defined, as for this research work elements from the Multi-level approach will be also used in order to make the analysis

more practical and engaging towards understanding what are the key elements which are constraining the effective management of water resources for the selected case-study.

3.4 Sustainable Management for Common-pool Resources Approach

The Institutional Analysis and Development Framework (IADF) was developed by Elinor Ostrom in order to illustrate and improve the understanding on the sustainable management of common-pool resources within common-pool resources governance and the eight principles developed by the same researcher around this concepts. Ostrom (2008) reviews the tragedy of the commons as the over-exploitation and degradation of the common resources. However, it is also stated that although common-pool resources tragedies are not inevitable, these can be avoided through small changes in the action situation (Hoffman & Ireland, 2013; and Ostrom, 2008 and 2011).

The action situation is actually the core of the framework developed by Ostrom, and it is basically the social spaces where individuals and organizations can have interactive activities such as exchanging goods and services, solving problems and even have dominance issues among different actors; therefore action situations are used to different things such as analyzing, describing, predicting and explaining behavior within institutional arrangements (Hoffman & Ireland, 2013).

Below, Ostrom's principles for managing commons are introduced and moreover some modifications and further analysis from Hoffman and Ireland (2013) are provided:

1. **"Define clear group boundaries":** within the boundaries that should be defined, users (to legitimate who are the users of a determined resource) and resource boundaries (to define the biophysical system) are identified.
2. **"Match rules governing use of common goods to local needs and conditions":** this is related to the adaptation of rules around the social and environmental conditions as well as the appropriation and allocation among users of the obtained benefits together with the inputs required to manage the common resource.
3. **"Ensure that those affected by the rules can participate in modifying the rules":** this principle is based on the public participation in the design and implementation of any management program in order to promote equity and community participation.
4. **"Make sure the rule-making rights of community members are respected by outside authorities":** cooperation among different levels should exist without external authorities interfering with local communities.
5. **"Develop a system, carried out by community members, for monitoring members' behavior":** within this monitoring Hoffman and Ireland (2013) also define the users as well as the resources monitoring and stating that accountability is a fundamental element for the monitoring processes.
6. **"Use graduated sanctions for rule violators":** for this principle, sanctions should be established depending on the degree of damage caused and these should be placed by the authorities as well as by the appropriators of the common resource.
7. **"Provide accessible, low-cost means for dispute resolution":** as disputes will likely occur in any resources management process, mechanisms should be in place in order to solve these conflicts in a cost-effective manner for the actors involved.
8. **"Build responsibility for governing the common resource in nested tiers from the lowest level up to the entire interconnected system":** this principle is grounded in the rationale that governance solutions should start by empowering from the lowest levels of society (individuals, households and local communities) as well as

organizations as a mean to an effective common resources management (Hoffman & Ireland, 2013 and Ostrom, 2008).

After analyzing the eight principles above mentioned, the following figure is presented in order to illustrate how these principles can be used in a framework for managing common pool resources:

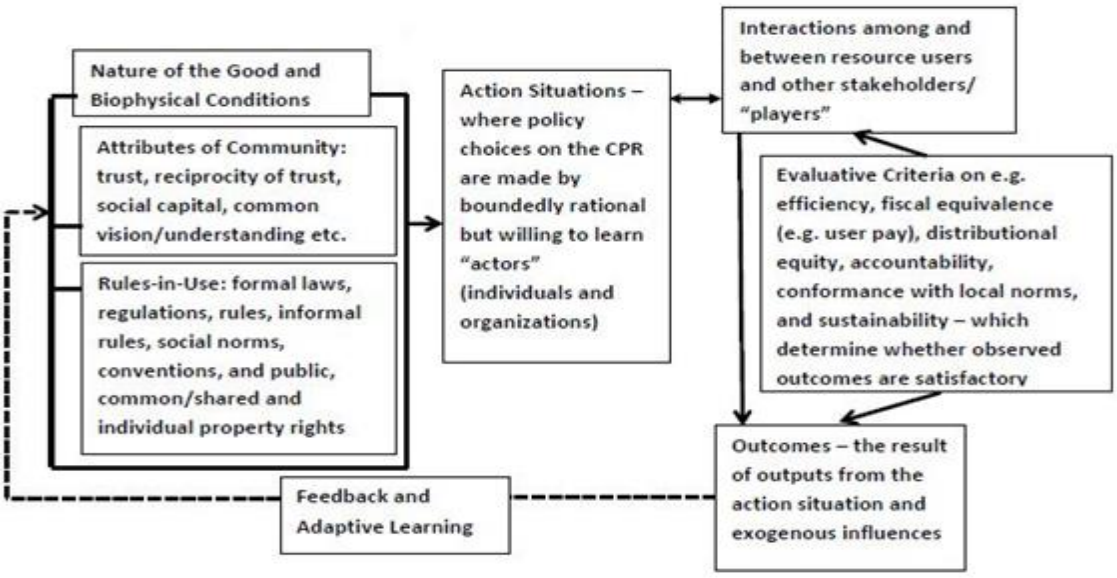

Figure 5 Institutional analysis and development framework (Source: Hoffman and Ireland, 2013)

Within the Institutional Analysis and Development Framework, the interactions between elements such as biophysical environment and the different communities together with the rules that are placed in order to define who are the players, how the 'game' works and the responsibilities that each of the actors should have, are combined in the action situation arena. These interactions are aiming to promote particular outcomes towards sustainable management of common resources. While these processes occur, an evaluation process is happening in order to assess if the objectives were accomplished and if changes in rules and players should be given; through this evaluation, feedback and adaptive learning is provided to the source and base of the process with the correspondent actors involved.

Although the IADF could be considered as a quite broad framework that introduces basic common-pool resource management principles, yet water is a fundamental common-pool resource. Given that particular elements, which will be described later in this chapter, were identified only in this framework, for the sake of the intended holistic analysis of the present research work different elements from this framework will be also considered.

3.5 Water Governance and Poverty Approach

The framework presented below is based on water governance and on how the outcomes are produced for the poor through complex societal processes (Cleaver & Franks, 2008).

In this framework, resources consist on non-material and material resources, which are then used by actors and agents in order to define the mechanisms in which access to water or water governance arrangements are established. According to Cleaver and Franks (2008), the mechanisms of access can be defined through custom rules, taken-for-granted negotiations

and social interactions. They also emphasize that these mechanisms should be context-specific depending on particular social and environmental context. Depending on the nature of the mechanisms established by actors and agents, different outcomes for both the poor and ecosystems can be given in both positive and negative manners, being able to reinforce, generate or diminish inequalities of access for the poor (Cleaver & Franks, 2008).

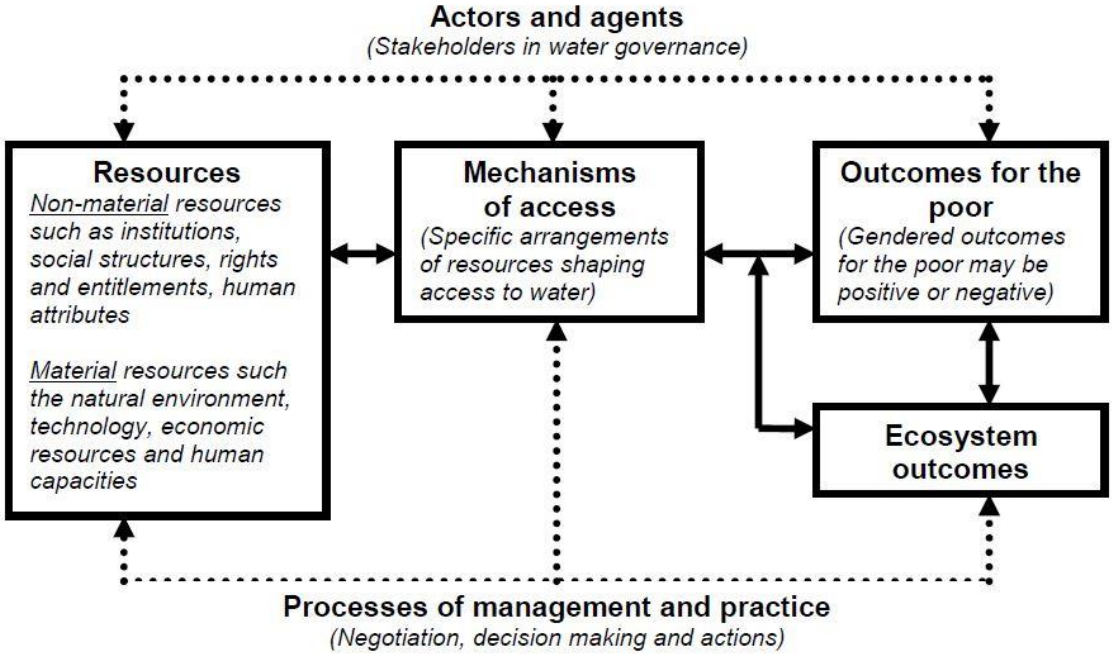

Figure 6 A framework for analyzing water governance and poverty (Source: Cleaver & Franks, 2008)

Cleaver and Franks (2008) also mention that among actors and agents, different levels of authorities can exist in order to command over resources and even to other actors. Furthermore, within the water resources management process, there are permanent, dynamic negotiation and decision-making processes with the corresponding actions taken to modify both mechanisms and responsibilities from the actors involved in the process; this with the final aim of modifying the outcomes for the poor and for ecosystems. For Cleaver and Franks (2008) 'good' governance is basically linked to the equity of the outcomes.

Given the poverty conditions within the case study that will be developed, this framework was also selected for this thesis work in order to further enhance the analysis of the relationship between poverty and water resources management.

3.6 A Conceptual Framework for Water Governance in Cuncani

In order to provide a conceptual framework which could be theoretically applied for policy design towards water resources management in a rural community such as Cuncani, key elements and/or principles from the approaches previously introduced were identified and then combined in an attempt to produce a more holistic conceptual framework which could be used in the particular context of the present thesis work. It is important to highlight that each of the approaches presented are perfectly valid and have been used in determined ways and in different contexts. However, as for the present research work there are no preferences for any particular framework, the review was done in order to gather key elements which

could serve as a baseline and a general framework which could be then contextualized for the analysis of the findings in this thesis work.

The first step into the analysis of the different frameworks was to identify key similarities between them; this also helped to identify agreement or disagreement among the different sources reviewed. It is also convenient to highlight the fact that these conceptual frameworks attempt to promote sustainability from both environmental perspective (by promoting sustainable management of water resources) and from the water access perspective (by promoting sustainable water access to communities).

Regarding common principles identified among the different frameworks, the baseline for each of them is basically the same; all the reviewed frameworks are aiming at the sustainable management of water resources and furthermore, they are working under the context of a finite water supply. Furthermore, the following common principles were identified among almost all the water management approaches reviewed:

1. **Participation as a fundamental element when developing a water-related project:** this principle was brought up in different ways by each framework; for example, the IWRM approach mentions the importance of public participation in the decision-making process (UNDP, 2004) whereas the Demand-based approach specifies the need of communities participating in the decision of key elements related to the technological and management systems and within all phases of a project (planning, execution and operation) (World Bank, 2011). Moreover, the Multi-level approach highlights the need of a more holistic approach towards enhancing the understanding of water issues and the fact that these are also related to education, participation and communication elements (OECD, 2011). Later, the Common-pool resources management approach states that public participation shall be given in both design and implementation processes of any management system (Hoffman & Ireland, 2013 and Ostrom, 2008) and finally, the water governance and poverty approach points out that there should be a permanent and dynamic negotiation between all relevant actors involved in the decision-making of a water-related project (Cleaver & Franks, 2008). Therefore, as for the present thesis research, the analysis will be given considering community' s participation as a fundamental element for the implementation of the D4field technology and for the analysis of the current elements constraining the effective management of water resources and the consequent access to these in Cuncani.

2. **Contextualization of water systems and related regulatory frameworks and institutional arrangements:** this is one of the principles that were highlighted the most within every water management approach reviewed. In this regard, the IWRM approach mentions that every country and/or community should establish their own regulatory frameworks having in consideration local conditions (UN & the GWP, 2007). Furthermore, the Demand-based approach adds to this that water systems should be context-specific in order to guarantee sustainability of them (World Bank, 2011). Moreover, the Multi-level approach distinguishes that all institutional arrangements depend on heritage and national values and therefore they should be developed based on every particular context conditions (OECD, 2011). On the other hand, the Common-pool resources management approach gives another perspective to this, pointing out that rules in which common-pool resources management are given should be adapted not only to the social context but also to the environmental context (Hoffman & Ireland, 2013 and Ostrom, 2008). Finally, the water governance and poverty approach focuses on the idea that water access mechanisms should be

developed depending on both environmental and social conditions (Cleaver & Franks, 2008). As for the present research work, this principle will also be included on the analytical framework that will be used, mainly due to the strong importance that is given to considering local conditions when designing and implementing any water-related project. Additionally, this principle can be considered not only for the regulatory frameworks and institutional arrangements but also within the characteristics of a technology that is to be implemented, given the fact that local conditions can both promote or reject the effective implementation and maintenance in time of a technology depending on social and environmental conditions.

3. **Effective regulatory frameworks and institutional arrangements as requirements to achieving sustainable management of water resources:** regarding this principle, the IWRM approach establishes that governments should be responsible for developing regulatory frameworks in order to work towards the sustainable management of water resources (UNDP, 2004). Moreover, the Demand-based approach points out that communities need external support in order to manage and operate their systems and therefore, convenient institutional arrangements should be given in order to provide this support (World Bank, 2011). On the same line, the Multi-level approach highlights that decentralization and self-organization requires institutional arrangements as well in order to provide them with support (Ostrom, 2008). Finally, the Common-pool resources management approach distinguishes the fact that there should be cooperation and support between the different actors and levels but no interference shall occur among the different responsibilities assumed by relevant actors (Hoffman & Ireland, 2013 and Ostrom, 2008). Due to the importance that is given to the regulatory frameworks and institutional arrangements within the reviewed approaches and given the fact that the research questions of this thesis work also relate to the institutional schemes that can support the implementation and maintenance of the D4field technology, the previously-mentioned principle will be also considered under the analytical framework that will be used to analyze the findings of this work.

4. **Water governance initiatives should start on the local level:** in this principle the importance of the role of the communities is highlighted. In this sense, the IWRM approach states that water should be managed at the lowest level in a community (UNDP, 2004). Additionally, the Demand-based approach establishes the community as the main actor on the water management, not only because water systems are based on their needs and preferences but also because community participation in every stage of a water-related project is fundamental if is to be sustainable (World Bank, 2011). On the other hand, the Multi-level approach focuses on the water governance responsibilities, stating that these should be disperse at different levels including the local level (Gupta & Pahl-Wostl, 2013). On the same line, the Common-pool resources management approach points out that governance solutions should be given by empowering the lowest levels of a society (local and community levels) (Hoffman & Ireland, 2013 and Ostrom, 2008). Given the fact that this thesis research will be based on a particular community as case-study, it will be quite convenient to consider the previously-introduced principle and have as main conception the importance of attributing responsibilities to the community and making it one of the most important actors within water management systems.

5. **Water systems should be managed not only from the supply-side but from the demand-side as well:** for this principle the IWRM approach highlights that working on both supply and demand side of a service provision is important in order to make a

service sustainable (UNDP, 2004). On the other hand, the Demand-based approach focuses on developing a water system which is fully adapted to a community's needs, preferences and furthermore, based on identifying the real demand for water in order to make a service more sustainable (World Bank, 2011). As for this research surveys directly into the community will be carried on in order to explore the demand-side of water services (among others), this principle will be conveniently considered in order to highlight the importance of the community's preferences and actual needs; this basically in order to enhance understanding into how possible or smooth will be to implement a new technology aiming to improve their water services and the possible sustainability on this service.

6. **The importance of having effective stakeholder participation and involvement within water management systems:** for this principle, the UN and GWP (2007) mention that in order to enhance water resources management and to better allocate these resources among the different water users, it is quite important to have relevant stakeholders participating in the whole decision-making process. Additionally, the OECD (2011) points out that as water management involves different administrative and territorial levels, this complexity makes necessary to have different stakeholders participating in every level, therefore it is of high importance to clearly define responsibilities in order to make water governance more effective. As one of the research questions of this thesis relates to the participation scheme and the responsibilities allocation among different and relevant actors within water resources management and more specifically within a technological implementation and maintenance, the just-introduced principle will be also considered within the analytical framework for this research.

7. **Strengthening gender participation and empowering women to enhance sustainability of water systems:** the importance of the role played by women on the provision and safeguarding on water resources is quite highlighted by the IWRM approach (UNDP, 2004) and furthermore, the Demand-based approach establishes that in order to promote the social conditions required to enhance sustainability of water services, the strengthening of gender participation is then fundamental (World Bank, 2011). Furthermore, as the previous literature review on Cuncani showed that there is a strong dominance of men over women to develop fundamental tasks within the community but yet women have strong responsibilities when it comes to household and children safeguarding (Nexos Comunitarios, 2012), therefore for this thesis the gender participation strengthening principle will be also considered in order to enhance the analysis on findings.

8. **There is a strong linkage between effective water governance and poverty alleviation:** as stated by the UNDP (2004) there is a fair tangible relationship between water governance, hunger and poverty alleviation, the improvement of health, education and the reduction of environmental degradation. Furthermore, Cleaver and Franks (2008) reinforce this idea from the poverty perspective by pointing out that water governance can promote different outcomes to the poor (both positive and/or negative outcomes) through complex societal processes. Therefore, as poverty is one of the elements present in the community in which a case study will be developed, this water governance and poverty principle will be considered on the analytical framework. Additionally, as health and education elements will be also considered and explored within this research, the relationship between water governance and these elements will be reinforced and enhanced.

9. **Promoting training and education is fundamental to enhance sustainability of water services:** in this sense, the Demand-based approach focuses on the knowledge and capability to implement and maintain a determined water system by a particular community (World Bank, 2011) whereas the Multi-level approach distinguishes the capacity gap as a knowledge issue not only in the operation and maintenance part but also in the water-related policy-making and design stages (OECD, 2011). In regard to this principle, knowledge in water systems and education on the importance of water will be evaluated within the community. However, as it is not the aim of this research, when it comes to the knowledge and capabilities from the relevant actors related to policy-making this will not be directly evaluated but indirectly explored through interviews and the focus group that will be carried on.

Additionally, besides the common principles just identified there are other important principles that were identified in a more isolated manner within some of the conceptual frameworks reviewed. For the sake and convenience of this research, the following principles will be also considered under the analytical framework:

10. **Promoting a payment culture among community members before implementing any water-related systems:** this principle is emphasized by the World Bank (2011) within the Demand-based approach and reinforced by the UNDP (2004) stating that a payment culture among community members is fundamental if a system is to be self-sustained and sustainable in time. Therefore, as a technological implementation and maintenance requires financial resources (among others) and the payment culture for water services within a community, this principle will be considered given the fact that evaluating the willingness and ability to pay from people will be done within the survey carried on in Cuncani.

11. **Developing a monitoring system for both resources and people's behavior:** as the monitoring stage is fundamental in order to evaluate the effectiveness and efficiency of any system, this principle should also be considered when implementing and maintaining any technology (Hoffman & Ireland, 2013; Ostrom, 2008 and World Bank, 2011). As monitoring is directly linked with the maintenance phase of a water-related project, this principle will be contemplated when evaluating the best scheme for actor's participation and involvement within both technological implementation and maintenance phases.

4 Water Solutions in Practice: Sustainability at the Community Level

Given the fact that a sustainable access to safe water is a basic service and a requirement for human development, the first thing that must be done is to define what a "sustainable service" is and what it involves. When it comes to selecting a water purifying technology there are many different elements involved that affect its sustainability in time (WHO & IRC, 2003). For example, the WHO and IRC (2003) emphasize that in the past there was a strong focus on technical and economical aspects when choosing and implementing a technology; but in current times it has been worldwide acknowledged that besides technical and economical aspects, sustainable technologies and services are also related to social, cultural, institutional and environmental aspects. In the present chapter, the aim is to review the different arguments in terms of what are the elements playing a fundamental role towards the achievement of a sustainable service and related technologies. In an attempt to provide a framework to analyse the possible implementation and maintenance of the D4field technology in a rural community such as Cuncani, there is a need to first identify what are the key elements that need to be considered during these processes.

4.1 Sustainability Criteria for Water Systems and Related Technologies

When it comes to sustainability of a service, WHO and IRC (2003) defines a water service as "sustainable" if: the service is properly functioning and is being used by the targeted population, which relates to the baseline element of having a demand for a determined service; is delivering both quality and quantity of water with easy access conditions and in a reliable and continuous manner; is providing health and economic benefits to its users; is providing its functions over a prolonged period of time, based on its life-cycle; the service management involves the community and additionally works under partnerships with local authorities and the private sector; the design of the service is done considering gender issues from every community; operation, maintenance, rehabilitation, replacement and administrative costs of the service are covered at the local level (when possible by fees paid by families) and/or through any alternative but sustainable financial mechanism; is operated and maintained by communities and (if needed) they can receive limited external support for technical issues and training; and finally, if it does not promote any harmful consequences for the environment (WHO & IRC, 2003).

However, different arguments and discourses were reviewed when it comes to sustainability of a service and/or a water system; in this sense, authors make distinction among different groups of aspects that should be considered if sustainability is to be achieved. For the sake of this work and to enhance understanding on the subject, relevant aspects were grouped into four main groups.

4.1.1 Social and Community Aspects

In terms of social and community aspects affecting sustainability of a water-related project, the main key success factors are related to participation from the community within all stages of a water project, gender equity elements and the fundamental role played by women participating in water management and finally, having a demand-based rationale within every project which implies having tailored or context-specific solutions for every community (Amer, 2004; Choe, 2005; Dale et al., 2008; Da Silva et al., 2012; Katz & Sara, 1998; Peter &

Nkambule, 2012; Spaling et al., 2014; Takanashi et al., 2010; UN, 2006; Whittington et al., 2008; WHO & IRC, 2003; Woka & Ibimina, 2014).

Regarding community management and participation within a water system, Takanashi et al (2010) state that this is a central element for achieving long-term sustainability. Furthermore, Amer (2004) points out the need to have participatory processes not only to improve water systems management but also to enhance the sense of ownership from a community. In this regard, Whittington et al (2008) highlight that in order to promote demand-driven approaches into water management it is necessary to involve households in the decision-making of not only technologies but also institutional and governance arrangements. Finally, Da Silva et al (2012) add to the previous statements that when the community participates in the whole planning of their water systems, these are to be more sustainable than the ones imposed by governments or external donors.

On the other hand, Barnes et al (2011) suggest that participatory approaches do not necessarily promote sustainable solutions due to the fact that these solutions will be promoted depending on the community's knowledge on the issues involved. On the same line, Takanashi et al (2010) highlight the importance of community's knowledge but in terms of understanding the relationship between water quality and health. Adding to this statement, Da Silva et al (2012) point out the relevance of understanding the relationship between water, health and growth as well. Therefore, it is emphasized the importance of promoting training among community members not only for technical issues but also to enhance their understanding towards the health benefits coming from a safe water supply; in this way, people will have a better knowledge and a more effective decision-making process given that the community will actually demand for a safe drinking water supply (Barnes et al., 2001; Da Silva et al., 2012; Takanashi et al., 2010).

Additionally, in order to support and promote water management from the community level, it is highlighted the importance of having water committees in charge of different management activities. For example, Choe (2005) points out as a success element to have a committee within the community in order to maintain water system, to tackle any issues with them and to select projects that are actually suitable for every particular community. Furthermore, the role of the community leaders is also highlighted due to its importance in disseminating technological innovation, planning and implementation of water projects (Choe, 2005). Moreover, Peter and Nkambule (2012) emphasize the importance of having an effective water committee within the community as a vital aspect for sustainability, not only to enhance water resources management but also to improve coordination among the community and the local leaders.

A relevant aspect regarding the responsibilities of operation and maintenance (O&M) of water services and systems is also mentioned. Amer (2004) mentions that a community should own and be responsible for the operation and maintenance of its water systems. Yet, Chantler (2005) states that operation and maintenance of water systems may be responsibility of water authorities and/or from a subcontract with a specialist on this. Arguing to this statement, Whittington et al (2008) mention that "Communities can and should take full responsibility for their systems" (p.20). On the same line, Peter and Nkambule (2012) highlight that community should participate in O&M activities in order to promote sustainability of a service and furthermore, Choe (2005) points out that sustainable development of a community is achieved through diligence, self-reliance and cooperation and thus communities should be in charge of their systems during both implementation and maintenance phases of a water project.

When it comes to gender equity elements, it is highlighted how fundamental is to have women performing their vital role when managing water resources (Choe, 2005; Peter & Nkambule, 2012; Whittington et al., 2008; Woka & Ibimina, 2014). In this regard Choe (2005) points out women as "change agents of a society" (p.11) and their role in water sanitation covering participation, deliberation and decision-making towards sustainable water services, and likewise as agents promoting training and education of communities which is vital for sustainable development.

Finally, elements related to community's trust in their water systems together with cultural aspects are also mentioned as crucial sustainability aspects. For instance, some cultural beliefs may support the idea of nature already providing safe water and there is no actual need of purifying water and creating a water provision system (Woka & ibimina, 2014). Adding to this, it is extremely important that communities trust in their water systems in terms of providing the required water quality for it to be safe (Takanashi et al., 2010). On the same line, Spaling et al (2014) emphasizes that trust must be developed and maintained through communication, shared information and coordination among community members in order to prove accountability and transparency in terms of effectiveness of water systems and the related management from community leaders.

4.1.2 Environmental Aspects

Environmental aspects are mentioned within sustainability from two different perspectives; the first one is related to the fact that due to the environmental degradation that has been increasing over time and that will likely worsen even more, previously installed water systems are worldwide breaking down because of their lack of resilience to the dynamic changes on the environment; this relates to both the availability of water and the changing climate patterns (Dale et al., 2008). Therefore, it is fundamental to consider environmental degradation and its dynamic changes over time when developing and planning a water-related project.

On the other hand, environmental aspects are also mentioned as a vital aspect to consider when developing a project and furthermore, when selecting a particular technology. In this sense, Dale et al (2008) states the importance of protecting the water source when designing a water system. Similarly, Spaling et al (2014) emphasizes the importance of the biophysical sustainability of a water supply and the relevance of carrying out an Environmental Impact Assessment (EIA) when evaluating both a water system and the technologies within this. In this regard, Hamstead (2009) states that it is fundamental to maintain the ecosystems health and its ecological characteristics when designing a water system with all its related parts. Furthermore, the Environmental Quality Board (EQB) (2008) highlights the importance of establishing long-term strategies towards including water sustainability assessments into any regulatory framework developed in a determined context.

Considering the key to environmental sustainability around the promotion of environmentally sound technologies and processes from the early design and implementation of any project (Ashford, 2005) and additionally, in view of achieving the MDG related to ensuring environmental sustainability, the United States Environmental Protection Agency [EPA] (2006) states that under the principle of preventing pollution to promote sustainability, the development of technologies and technological innovation should guarantee environmental protection while avoiding environmental harm. In this regard, it is mentioned that a symbiosis between renewable energies and water-related technologies can promote both a safe drinking water supply while avoiding environmental degradation (EPA, 2006).

4.1.3 Financial and Institutional Aspects

According to Peter and Nkambule (2012), although the technical and social/environmental factors are quite critical, institutional and financial factors play a necessary role when promoting sustainability of water services. Therefore, as for this literature review, financial and institutional aspects will be reviewed as well.

When it comes to institutional aspects, Choe (2005) states that the role of governments (both local and national) is fundamental in terms of providing support and interventions when necessary. In this regard, it is noticed that national governments should establish guidelines and a clear regulatory framework from which local governments should base their activities on (Amer, 2004; Chantler, 2005; Choe, 2005; Woka & Ibimina, 2014). Adding to this, Amer (2004) states that governments should be responsible not only for developing and implementing policies but also for placing effective enforcement mechanisms. Moreover, governments are responsible for the right infrastructure provision and of establishing the most advisable working practices for communities (Amer, 2004). However, Chantler (2005) clarifies that local governments should be able to perform their functions without being affected by the national government. Additionally, Woka and Ibimina (2014) make the distinction that in order to promote the integration and adherence of relevant stakeholders into regulatory policies and guidelines, these should be clearly defined and consistent.

Furthermore, most of the authors agree on the statement of having a combination of bottom-up and top-down approaches towards effective water management systems (Choe, 2005; and Takanashi et al., 2010). In this regard, Choe (2005) mentions that national governments are responsible for providing the required management framework and may give the first step into water management initiatives. In addition to this, Takanashi et al (2010) suggest that top-down approaches are required to improve water treatment facilities and to monitor quality and quantity of a water service provision; yet, bottom-up approaches and the involvement of community in decision-making and maintenance of their systems is fundamental as it plays the role of facilitating a sustainable management.

Equally important, regarding institutional arrangements among different societal actors, there is a general agreement on the fact that public-private partnerships are quite convenient for water systems management (Amer, 2004; Da Silva et al., 2012; Johnson et al., 2006; Woka & Ibimina, 2014). In this respect, Amer (2004) highlights the importance of linking communities with governmental entities and different organizations in order to obtain the support that a community needs to manage their systems. Moreover, Da Silva et al (2012) suggest that linkages between governments, private businesses and communities are highly convenient to improve the effectiveness of water systems management. Additionally, Woka and Ibimina (2014) indicate that water services should be managed at the lowest levels required and this should include local and national governments as well as the private sector and non-governmental organizations. In addition, regarding the role of non-governmental organizations, Johnson et al (2006) suggest that these may function as partners with private investors in terms of providing support in the evaluation towards selecting a technology that is culturally and economically accepted by a particular community.

On the other hand, regarding financial aspects that can affect the sustainability of a water-related project, it is stated that communication with every community is quite important in terms of reaching an agreement point in which community members can actually manage and cover operational and maintenance costs of their systems; it is crucial for sustainability to evaluate the community's financial capacities so the water system can be effectively operated at a reasonable cost (Dale et al., 2008; Da Silva et al., 2012; Peter & Nkambule, 2012). Moreover, Takanashi et al (2010) emphasizes the importance of water committees to set

affordable water fees depending on the community's willingness and ability to pay. Likewise, there are different arguments presented around the controversy of who should be responsible of paying for initial implementation costs and later for operation and maintenance costs. Most of the worldwide aid and donor organizations are against charging for water services in vulnerable communities due to the fact that people are living in poverty conditions. Moreover, most of poor people are caught in a "poverty vicious cycle" covering poor health, education, financial conditions and poor water and sanitation; therefore, there is an argument stating that if worldwide aid organizations can contribute with the improvement of water and sanitation conditions from poor communities, they will contribute to breaking the poverty cycle (Whittington et al., 2008, p.6).

Adding to the previous arguments, Amer (2004) mentions that one important obstacle to achieve financial sustainability of water services is the lack of access from communities to cash; therefore, it seems quite difficult to actually establish a convenient tariff collection system in these cases. However, arguing with this, Whittington et al (2008) suggest that demand-driven approaches require that households pay for all operation and maintenance costs and at least a part of the initial implementation costs; in this way, a sort of demand-filter can be established and people will pay for a service that they actually need and demand for. Likewise, having people paying for initial investment costs will promote their sense of ownership on their assets, which is fundamental for the sustainability of any service (Whittington et al., 2008). Furthermore, Choe (2005) points out that providing incentives to communities through grants and loans from the governments may work as an approach to tackle the community's lack of financial resources and more particularly their lack of cash.

4.1.3.1 Entrepreneurs Participation and Engagement

Given the previously-mentioned importance of Public-Private Partnerships (PPP) within the management, operation and maintenance of water systems and furthermore, in the interest of Watersprint AB and different entrepreneurs who have the motivation and interest to participate in the creation of value to improve rural water systems; as for this thesis the role of the private sector and entrepreneurs will also be reviewed within the institutional aspects towards the sustainability of water services.

It is stated that entrepreneurs currently have a great importance when it comes to guaranteeing the sustainability of a service; in this regard, entrepreneurs not only have the responsibility and the challenge as technology developers based on the identification of an unmet need, but they also have the task of participating and entering into markets which could represent complex challenges due to different cultural, political and economic factors that could constrain and/or boost their success (Newborne & Mason, 2012; Tiwari & Bonaya, 2011; and Tova, 1998). In order to achieve both sustainability of a service and success for an entrepreneur, there is a general agreement on the idea that innovation is a fundamental element that should be considered. When it comes to innovation, it is not only in regard of technological creativity itself but also the importance of tailoring the service for a particular community (Kaburi et al., 2012; Tiwari & Bonaya, 2011). For instance, Kaburi et al (2012) emphasize the acknowledgement of cultural and ethnic aspects playing a fundamental role in terms of the different attitudes and behavior of entrepreneurs that are to be successful in meeting people's needs.

Equally important, there is also a general agreement on the fact that O&M tasks are the major challenge when trying to achieve sustainability of water services and in this sense, communities require support when it comes to technical services, accessibility of spare parts and all the capabilities required to guarantee the sustainability of water services (Tiwari &

Bonaya, 2011). Therefore, it is highlighted the need of implementing an approach in which community-based management could be successfully combined with private sector participation towards improving the efficiency and sustainability of O&M activities within water services (International Bank for Reconstruction and Development [IBRD] & World Bank, 2013; and Kleemeier & Narkevic, 2010). In this regard, Foster (2012) mentions that entrepreneurs and the private sector are increasing their participation within water services given the low levels of sustainability achieved by pure community-based models and furthermore, Patel and Chavda (2013) and Kleemeier and Narkevic (2010) agree on the fact that the lack of sustainability is due to the lack of capacity, education and training among community members. In this case, Foster (2012) emphasizes that entrepreneurs have the potential to not only improve the efficiency on the services provided but also to reduce the dependence of communities on local governments and external organizations.

However, regarding the possibility of entrepreneurs participating in water services, the Kleemeier and Narkevic (2010) highlight that a key element is the achievement of the enabling environment to encourage their participation. Furthermore, it is pointed out the importance of governments and their role of both setting the legal framework to foster entrepreneurs participation and to regulate their performance and additionally, of providing funding and/or subsidies for water projects when required by a particular community (IBRD & World Bank, 2013; Kleemeier & Narkevic, 2010). In addition, IBRD and World Bank (2013) conclude that although the private sector can have a better technical and managerial expertise, this cannot cover governmental functions and responsibilities.

On the other hand, when it comes to financial sustainability there are two main aspects of it which need to be considered, the short term sustainability which relates to the establishment of community-based fees in order to cover O&M-related tasks and, finally the full cost recovery which is related to the recovery of capital investments made (mostly in case of entrepreneurs investing also in water infrastructure) (Tiwary & Bonaya, 2011). However, it is emphasized the importance of keeping the affordability on water services while delivering safe water (Foster, 2012; Kleemeier & Narkevic, 2010). In this sense, Tiwary & Bonaya (2011) conclude that innovations are required in order to determine the best models in which both communities and entrepreneurs can obtain benefits from sustainable water services while at the same time receiving support from governmental and policy frameworks.

4.1.4 Technical and Capacity Aspects

Regarding technical aspects for the sustainability of a service, there is a general agreement on two main elements affecting technical sustainability; the first one is related to the technical knowledge and capacity from a community to operate and maintain their services. In this regard, it is highlighted that technical knowledge should be enhanced through constant training and education in order to provide the community with the technical capabilities required to operate and maintain their systems (Amer, 2004; and Takanashi et al., 2010). An additional element regarding technologies is pointed out. According to Amer (2004) another important element towards the achievement of technological sustainability is to involve the community in the technology choice; this is fundamental to guarantee that technologies are cheap, simple and preferably locally produced and maintained.

The second element is related to the importance of availability of spare and replacement parts for a particular water system and/or related technologies (Dale et al., 2008; Whittington et al., 2010; Woka & Ibimina, 2014). Spare parts of a system and related technologies are brought up as a crucial sustainability element given the fact that quality, availability and procurement of these can be quite challenging for some developing countries and more particularly for

isolated rural communities. Therefore, it is suggested that markets should have a stronger relationship with their direct beneficiaries (Woka & Ibimina, 2014). Concluding with this, Whittington et al (2010) remarks that if spare parts are available and communities have the required knowledge, they will be able to assume the full responsibility of operating and maintaining their systems without much external support.

When it comes to capacity aspects that affect the sustainability of a service, the main element that is highlighted is the management capacity of a community; in this sense, it is remarked the need of strengthen capacities, management skills and willingness from communities to assume the full responsibility and ownership when managing their water supply systems after the implementation phase is achieved (Amer, 2004; Dale et al., 2008; Takanashi et al., 2010; and Whittington et al., 2010). Similarly, it is again emphasized the importance of community training and education as a key element of sustainability. Furthermore, Takanashi et al (2010) points out that training and capabilities strengthening should have a strongest focus on water committees given the fact that these have the daily and closer responsibility for manage water supply systems.

4.2 Additional Remarks on Sustainability of Water Services

An important remark made by Dale et al (2010) and WHO and IRC (2003) is that any water-related improvement initiative must come together with hygiene and sanitation actions. Basically, even if access to improved water services is provided, having poor sanitation and hygiene conditions will most likely constrain the efforts on water sanitation and will reduce health and economic benefits achieved from these; therefore, it is quite fundamental to maintain the promotion and education on health and proper sanitation practices (Dale et al., 2010; and WHO & IRC, 2003).

On the other hand, in terms of sustainability in time of any project Spaling et al (2014) highlight the importance of the variability in time of the elements involved in a certain project. For instance, it is stated that most community-managed projects assume a constant supply of water, invariable water policies, permanent climate conditions and a constant management capacity from community leaders. In this regard, Spaling et al (2014) suggest how fundamental is to consider the variations on time of different factors; society and the environment are dynamic in every sense. Therefore, if sustainability is to be achieved, an integrated approach that considers changes in time must be implemented. For the development of such approach, it is recommended to use a scenario setting considering all possible changing elements; in this way it is possible to establish under the different circumstances what are the capabilities that need to be strengthen within each particular community (Spaling et al., 2014).

In conclusion, the present chapter reviewed different discourses and arguments around the considered most crucial and fundamental sustainability elements in order to provide a framework for the analysis of the findings for this research work in Chapter 6. Considering that sustainability on the implementation of the D4field technology is to be achieved, thus social, community, financial, institutional, technical and capacities factors will be considered when analyzing the possible institutional arrangements that could fit this particular technology and what are the key elements in which a strong focus should be given in order to guarantee a sustainable and safe water supply for Cuncani.

5 Findings

In the present chapter the findings of this thesis research will be presented. In order to enhance the readers understanding, findings will be divided according to the most relevant activities carried on based on the methodology previously introduced. Therefore, the findings from the interviews, the survey in Cuncani and finally from the focus group will be presented.

5.1 Interviews: Relevant Contributions

With the aim of covering in a clear manner all the different statements, contributions and ideas presented by each of the interviewees, this section will be divided according to the relevant actors within water services management in Cuncani. Therefore, as for this thesis research the actors or stakeholders considered as relevant were the Municipality of Urubamba, the Lares Health Center, NGOs (in this case Desea Peru) and Private Businesses (in this case the two companies mentioned in the methodology chapter). In order to go further into the interviews content, within the Apendix II of the present thesis work all the questions made in each of the interviews can be reviewed.

5.1.1 Municipality of Urubamba

During the interview with the representative from the Water and Basic Sanitation Office of the Municipality of Urubamba the following comments were made (E. Rodriguez, personal communication, February 11, 2015).

- ✓ The Ministry of Health (DIRESA) is actually in charge of water quality monitoring in Cuncani and for all rural communities within Urubamba's Disctrict. In case of Cuncani, the DIRESA has delegated water quality monitoring activities to the Lares Health Center (due to the closest location to Cuncani).

- ✓ Two water quality revisions are carried out by year and these results are kept by the Lares Health Center and the DIRESA. Only in case of a problem with water quality, the correspondent institutions will let the Municipality know in order to take the required measures to maintain water quality within the safe level.

- ✓ The Municipality of Urubamba ideally performs water systems monitoring activities once per month. However, the interviewee pointed out that due to constant personnel rotation monitoring tasks are not always constant.

- ✓ The Municipality of Urubamba has attributed to the JASS on each community the responsibility of operating, maintaining and the general management of their water services.

- ✓ In case of Cuncani, although they have received proper training, there are many difficulties with the JASS's work; this to their lack of responsibility for providing good services for their own community.

- ✓ According to the interviewee, as water comes from natural springs from the mountains, it is fairly clean and safe for human consumption. However, water gets contaminated at the end of the piping system when it gets in contact with animal's feces and therefore, when this happens there is presence of fecal coli forms in water but in minimal amounts.

- ✓ The only water treatment that is being applied in Cuncani is chlorination. The Municipality carries out the respective maintenance to the whole water system once per year.

- ✓ Cuncani has promoted a strong resistance to accept chlorine because they believe it is a toxic chemical and this is why the interviewee believes that the JASS has not been interested in properly managing their water systems including the chlorination process.

- ✓ Chlorination can provide safe water. This method is used because is of easy access in the market and people knows how to use it.

- ✓ The interviewee highlighted that if any new technology is to be brought into these communities, the market should guarantee the existence of spare parts and the knowledge to repair or to cope with any problem.

- ✓ Regarding the relationship between the Municipality of Urubamba and the Regional Government, the interviewee stated that they receive training programs for their workers and that Regional authorities provide the municipal budget.

- ✓ In regard of the institutionalization of the Water and Basic Sanitation Office in the Municipality of Urubamba, the interviewee pointed out that they have some limitations regarding personnel; there is constant rotation of personnel and therefore the training and time invested on them is lost. Additionally, there is a fair limited budget to their daily operations. Finally, barriers related to political will can sometimes constrain our activities and performance in terms of the approval of required budgets.

- ✓ When it comes to training and education, the interviewee mentioned that the Municipality provides training not only to the JASS members but also to the community members in terms of hygienic practices and proper use of water. However, people seem to not retain this information for much time.

- ✓ Regarding maintenance of their chlorination systems, the Municipality also provides the required chlorine so Cuncani's members only have to pay for daily maintenance activities performed by JASS members.

- ✓ There is also lack of interest and willingness from community members to monitor the JASS activities and for demanding proper water services. Therefore, there is lack of compliance of community's internal rules when it comes to JASS work.

- ✓ JASS members work is voluntary and there is no obligation from the community to pay for their services; this obviously influences their performance. All community members have to work in their land and cattle all day and if they are not properly paid, they will not have the interest of performing a work such as the JASS one.

- ✓ In case of a new technology, the Municipality is able to develop a project and allocate the required budget, however this will not make any sense unless people accepts the technology and are willing to maintain it.

- ✓ Communities have got used to receive free things from NGOs and from the Municipality. Therefore, there is no actual payment culture among them and no caring about the free things they get.

- ✓ Regarding the possibility of creating partnerships between the Municipality, private businesses and different organizations to implement a technology, the interviewee stated that this is possible as long as community members assume their responsibility and pay at least for maintenance activities of the technology.

- ✓ The interviewee does not believe in lack of resources itself but in lack of willingness from people to do things right.

5.1.2 Lares Health Center

During the interview with the representative from the Lares Health Center, the following comments were made (M. Vasquez, personal communication, February 20, 2015).

- ✓ The most common diseases in Cuncani are related to acute respiratory infections (due to the tough weather) and several cases of diarrheic diseases and stomach parasites as well.

- ✓ The most common stomach diseases are diarrhea and parasitic infections. Most common parasites are Giardia, Ascaris and Strongyloidiasis, which are related to water quality and lack of proper hygienic practices in each household.

- ✓ The most important and vulnerable group of patients suffering from these diseases are children.

- ✓ The interviewee pointed out limitations regarding both medical supplies and qualified personnel. First, there is no qualified biologist to perform laboratory exams in order to identify the bacteria and provide the correct medical treatment. Additionally, in case of particular and not-so-common diseases (like Strongyloidiasis), there is a bureaucratic and long process to obtain medical supplies to treat them.

- ✓ When the Health Center does not get proper medical supplies they try to create partnerships with both NGOs and/or private companies in order to obtain their support.

- ✓ Chlorination method does not guarantee 100% pathogens removal.

- ✓ Although the Health Center has a good relationship with the DIRESA, as even the Health Ministry has its own deficiencies in terms of qualified personnel, this makes the daily work more difficult.

- ✓ Lack of political willingness and the constant rotation of public authorities were also brought up as elements that can slow down the work pace of Health Institutions.

- ✓ Health monitoring programs are carried out in Cuncani by the Lares Health Center. However, due to lack of interest and lack of communication between the Health Center and the community, people do not attend to them, as they should.

- ✓ Whenever there are JASS meetings in the Municipality of Urubamba, the Lares Health Center sends a person to provide training in hygienic practices and health affectations coming from poor water quality.

- ✓ The government developed a program to improve health in rural communities by constructing vigilance centers in each community in order to avoid walking long distances

to obtain medical care. However, although this center was also built in Cuncani, there are still no doctors allocated to work there.

- ✓ Although the Health Center has trained people in order for them to avoid getting ill over hygiene and water-related diseases, people tend to quickly forget what they have learned.

- ✓ Cuncani is a vulnerable community in terms of their weak education, they need constant training so they can actually learn and retain knowledge at a long term.

- ✓ Not all community members are aware of the health consequences coming from poor water quality, even though they have received that information from the Health Center.

- ✓ Regarding public health, most people have a public health insurance that provides them with the medical treatment they need. However, the interviewee highlighted that people tend to not trust in the prescriptions the Health Center provides and sometimes they look for different opinions from regular private physicians; this fact can make them significantly increase their health expenditure since the public health insurance does not cover those expenses.

- ✓ When it comes to water quality monitoring, the process starts with the samples taken from three main points of the water system (before and after the chlorination system and in faucets from different households location), then the samples are taken to the Water Laboratory from the DIRESA and from these results, a report is sent to the Municipality of Urubamba so they can take the required measures to improve water quality (if needed).

5.1.3 NGO Desea Peru

In order to enhance understanding on the following comments, it is important to highlight that this organization has distributed a number of biological sand filters in order to purify water in the town of Lamay- Cusco Region. During the interview with the founder of the NGO Desea Peru the following comments were made (S. Hart, personal communication, January 30, 2015).

- ✓ The NGO Desea Peru started their work in Lamay town due to the fact that people were consuming contaminated water and this was bringing serious health issues for them.

- ✓ In case of Lamay town chlorine is their current water purification method. However, the interviewee mentioned that it is not being operated in the proper manner; in this regard, not enough residual concentration is being left and therefore pathogens are not being totally removed.

- ✓ Chlorine is proven to not remove all the bacteria from water. However, authorities do not know this fact and they believe chlorination is enough to correctly treat water.

- ✓ In order to promote sustainability Desea's programs, they have promoted education and training activities for community members so they can understand how to use their water filters and the health benefits coming from safe water consumption.

- ✓ So far this NGO has not charged anything to communities. They have covered health and educational programs besides most of the water filters. However, the interviewee stated that in the future they are planning to charge approximately 5 dollars per filter and no maintenance fee will be required given the fact that filters are fairly easy to maintain.

- ✓ The water filters were tested by the Ministry of Health and were approved as an effective method to purify water.

- ✓ The Municipality has afforded around 100 out of the 500 filters (approximate value) that this NGO has distributed. However, there is no additional support from public authorities when it comes to health and educational programs developed by Desea.

- ✓ In case of Lamay town, the interviewee highlighted that as JASS activities are voluntary work people tend to not participate and their work is not noticeable. In addition to this, JASS does not receive training or any motivation from public authorities. In this regard, instilling a payment culture is highly important to guarantee the sustainability of a service.

- ✓ Among elements contributing to sustainability are education and training, constant monitoring of people and their hygiene habits. Additionally, to know that quite complex technologies will not be properly used and managed by communities; therefore, maintenance is another key element.

- ✓ The main barrier faced by this NGO when implementing and maintaining their projects are related to the community's culture; changing people's behavior and habits is quite difficult as well as to effectively communicate with them.

- ✓ Women have shown a strong interest in participate on the NGO's educational programs and to assume leadership in their own households regarding health, water and hygiene. Men have shown more interest to the functioning of the filters and their maintenance.

- ✓ Maintaining the acquired knowledge at a long term was also highlighted by the interviewee as a key element towards sustainability. In this regard, was stated that people tend to quickly forget and to lose interest in the things the NGO have taught them.

- ✓ It is quite convenient to develop a previous study before implementing any new technology; in this regard, the interviewee highlighted that there is need for simple, cheap and effective systems in order to achieve health improvements.

- ✓ It was stated that there is a fair low willingness to pay for things other than food or something that will provide people from this type of communities with a direct income.

- ✓ When it comes to the technology itself, even if it has a 3-year warranty, the interviewee recommended having a person to monitor the proper use of it and people's satisfaction. Additionally, the device should be weather resistant and hardy to physical strength from people trying to manipulate it and could break it.

5.1.4 Private Businesses

5.1.4.1 HARBEC Plastics

As for this section, it is important to highlight that this company is the manufacturer and distributer of a water-purifying device called the Better Water Maker (BWM), which also works through UV-light; this device has been distributed as a donation among Africa, Asia and Latin America. Furthermore, the BWM was provided to Cuncani's school in the year 2010 (M. Valdivieso, personal communication, 2015). During the interview with the co-founder of HARBEC Plastics the following comments were made (K. Chamberlain, personal communication, February 4, 2015).

- ✓ No specific studies were carried on before bringing the technology to Cuncani but a survey was carried on after the implementation of the device to evaluate people's satisfaction on it.

- ✓ The device was introduced to community members during an assembly through the support from the NGO Nexos Comunitarios.

- ✓ The interviewee mentioned that according to her knowledge, no water treatment other than boiling water was being used in Cuncani. Children did not understand how water could be pure when using the BWM if it does not come out being warm; therefore they were introduced to the functioning of UV-light.

- ✓ People do not drink too much water unless for hot tea, especially during cold season.

- ✓ The interviewee highlighted that their aiming is to work as producers and distributers of the BWM and for the monitoring, operation and maintenance phases the company looks for partnerships with NGOs. However, it was pointed out that so far this has not been successful and that the company lost contact with most of their placements.

- ✓ No donations will be done in the future by this company given that based on their previous experiences, people give a higher value to things that they actually pay for. The company expects that once people understand the benefits (including reduction on health expenses) they will obtain from the BWM they will be willing to pay for it. The device will be sold in the future at a price of 100 Dollars per unit.

- ✓ Communication and language, transportation costs and changing people's behavior to make them understand that there is a problem with their water, were mentioned as important barriers for the implementation of the BWM.

- ✓ No relationship with local authorities, only with Nexos Voluntarios.

- ✓ The interviewee did not have any solid knowledge on the JASS from Cuncani.

5.1.4.2 Buen Power Peru

At this point it is convenient to point out that Buen Power sells energy-related products (mostly lamps) made with solar panels. Additionally, this company has managed to reach and sell its products mostly on rural communities (including Cuncani). During the interview with the co-founder of Buen Power Peru the following comments were made (A. Kozuch, personal communication, March 16, 2015).

- ✓ This company started its work based on its perception of energy needs in rural communities. They first installed two solar panels in a community and after people showed a strong interest and asked the co-founder how to bring a technology like that into their households, the interviewee stated that from that point they decided to start a company to sell energy products.

- ✓ In terms of sustainability on time, the interviewee stated that the first element is their products being affordable. Secondly, it was emphasized that people actually demanded for energy-products because they perceive a strong value on these services.

- ✓ The company works with small entrepreneurs who buy their products and then resell them directly in the communities; in this way, geographical barriers are overcome.

- ✓ Buen Power Peru also works with subsidies from NGOs and different organizations (USAID, NESST among others) so they can make prices more affordable.

- ✓ The company has a 2-year warranty on their products but they should last around 5 years; training is provided whenever people buy their products with relevant instructions so they can use and maintain the products.

- ✓ The company has intended to work with local authorities to implement their products in community projects. However, the interviewee highlighted that it is quite difficult to work with them due to corruption and lack of political willingness.

- ✓ Among their key success elements are the reputation they have built on their products quality, the fact that the other co-founder is Peruvian, has knowledge on community's cultural aspects and speaks Quechua dialect to effectively communicate with people.

- ✓ Among the main barriers were lack of education and lack of long-term vision from people. Due to the way NGOs and local authorities have worked, communities are used to receive things for free; in this regard, the interviewee made emphasis on the fact that governments are not willing to build capacities among communities.

- ✓ The company has managed to keep affordable prices in their products while covering their profit margins by having external donors subsidizing part of their products and by diversifying their products catalogue; in this regard, Buen Power Peru has developed products targeted for people living in the cities and with a higher purchasing power.

- ✓ In case of the water field the interviewee believes that there are many barriers that still need to be overcome; in this sense, as people do not see an immediate tangible benefit from improved water services, it will be harder to make them demand for these. Health expenditures are not a key element given that communities do not normally attend to a doctor unless they are quite critical on health. Their perception on being "healthy" is another key element; communities take for granted that they will be sick as long as they live in the mountains under rough conditions.

- ✓ The interviewee suggested to first putting a strong effort on educating communities so they are the ones actually demanding for improved water services, in this way they will be interested in maintaining their systems.

5.2 Survey in Cuncani

Regarding the survey activity carried on in Cuncani, as previously mentioned in the methodology section, the survey was divided into three different sections with related questions for each. Therefore, as for this thesis report results will be given according to the division of the survey's questions. The questions of the survey can be reviewed on the Apendix IV of the present thesis.

First of all, it is important to highlight that for this survey activity there was a 97.4% response rate, which means that 37 out of the 38 consulted families agreed to respond to this survey. Additionally, 20 interviewees were men (54%) and 17 interviewees were women (46%); this basically depended on who was available in the household to answer the survey. In some cases both man and woman were present during the survey but only one of them replied to the questions.

5.2.1 General Issues and Health

As can be seen in Figure 7, 94.6% of Cuncani's families obtain their water from the faucets outside their households; whereas 5.4% obtain their water directly from the river. Additionally, the families that obtain their water from the river agreed on the fact that this water is polluted. Furthermore, as seen in Figure 7, 54.3% of the families obtaining their water from faucets believe that this is polluted. Most of them mentioned that the water is not being properly treated with chlorine or it does not even have chlorine.

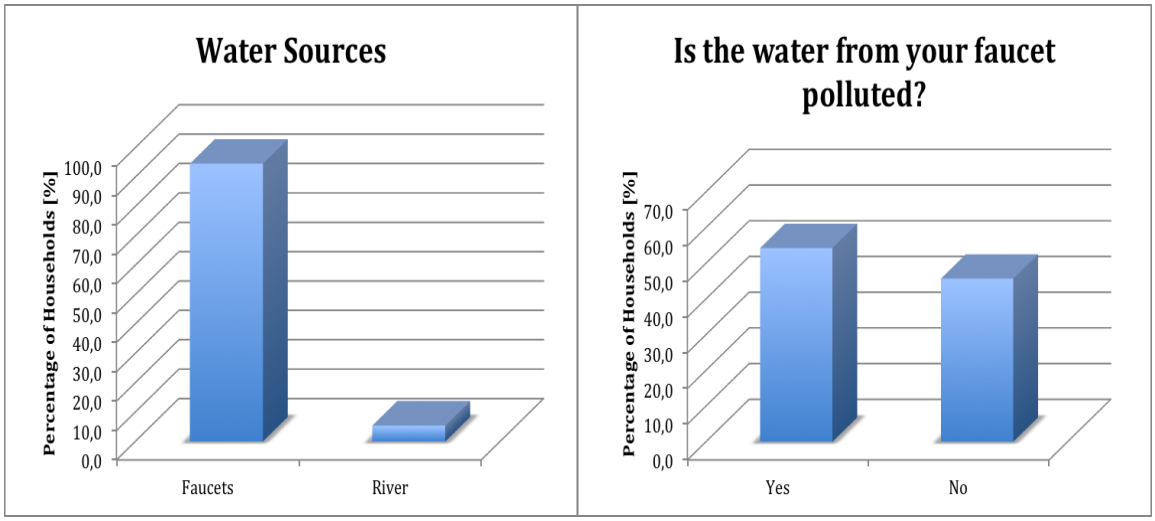

Figure 7 Water sources in Cuncani and contamination from faucet's water

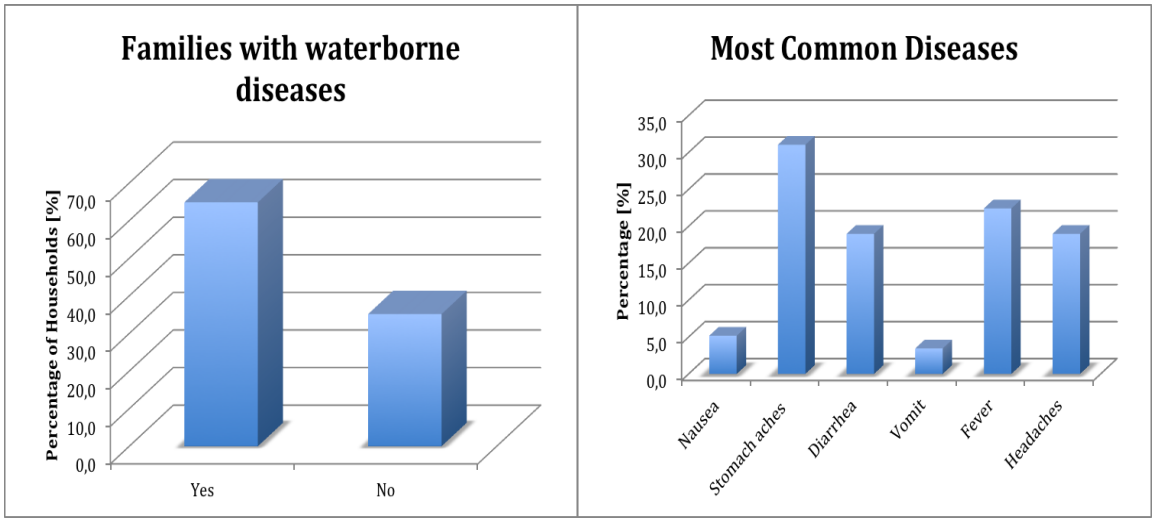

Figure 8 Families with waterborne diseases and most common diseases in Cuncani

When it comes to stomach-related diseases, 64.9% of the households (24 families) claimed to suffer from at least one of the diseases that could be related to poor water quality (Figure 8). Furthermore, among the most common diseases, in Figure 8 can be observed that these are stomach aches (31.0%), fever (22.4%), diarrhea (19.0%) and headaches (19.0%). Finally, it is of general agreement that children are the most vulnerable to suffering from these diseases.

Additionally, it is important to emphasize that from the 24 families that claimed to suffer from the previously-mentioned diseases only 11 of them (45.8%) directly related their stomach diseases with poor water quality; from the remaining families, 25.0% firstly related their

symptoms with improper hygiene, malnutrition and cold weather, 12.5% claimed that their water is not polluted and therefore their stomach diseases are not related to water quality, 8.3% claimed that water is polluted but this does not affect their health, and finally 8.3% claimed that their water "has microbes" but they did not know what are the consequences from these to their health.

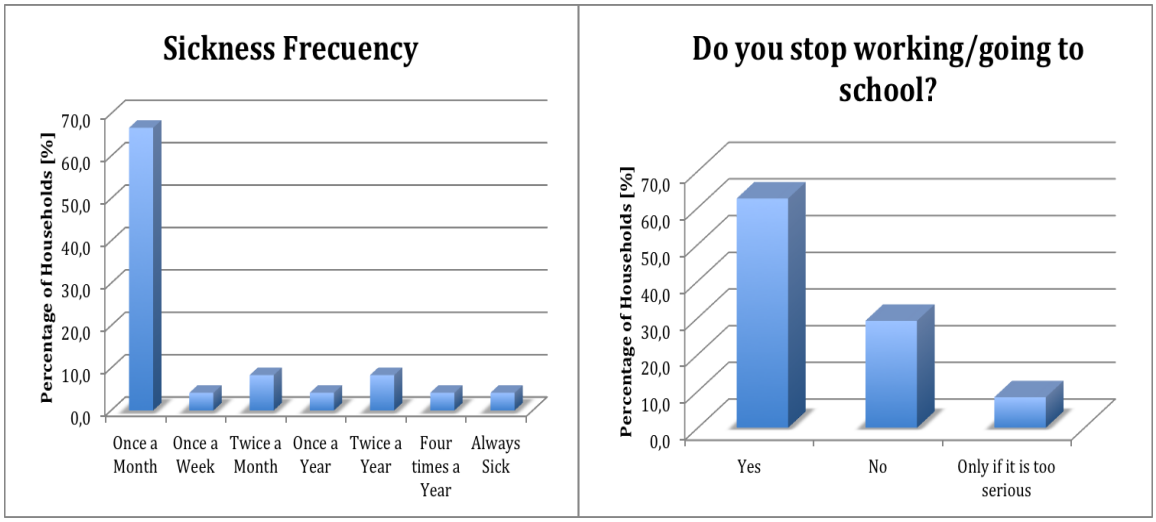

Figure 9 Stomach-related sickness frequency and productive days interruptions

Regarding the sickness frequency, 16 out 24 families (66,7%) reported getting sick approximately once per month. 33.3% reported more disperse times like once a week, twice a month, once and twice a year, four times a year and a particular elderly couple who claimed being "always sick" (Figure 9).

Additionally, in regard to the affectation of waterborne diseases on the community members' daily activities (including working and going to school), in Figure 9 is illustrated that from the 24 families that claimed getting ill, 15 (62.5%) mentioned that they do have to stop going to work and/or school; five (20.8%) claimed that they do not normally stop working, two families (8.3%) stop working and/or going to school only if the illness is too serious, and two families (8.3%) said that they cannot stop working even if they are ill.

Similarly, with respect to the duration of the illness, as the range given by the different families was relatively wide, for the convenience and understanding of the present findings in Table 1 averages are given for frequency and duration of the illness. Furthermore, based on the responses on the families that do stop working and/or going to school, an average of work and school days lost is also given (Table 1).

On the other hand, when it comes to health expenditure (on water-related diseases), 75.0% from the families who reported getting ill similarly reported expenditures but with a quite wide range; mostly depending on whether they decide to spend in transportation in addition to medicines, the type of health care they decide to obtain and the type of transportation they use to reach a particular health center. Similarly, for the sake and understanding of the present findings, considering the responses of the families who actually have health expenses, an average on health expenditure per each illness episode is given in Table 2.

As can be seen in Table 2, 25.0% of the families did not report any health expenditure; mostly because their public health insurance covers some of the medicines, others because they use

natural herbs to cure themselves, and finally because some families were not able to report an average on health expenditure.

Table 1- Average frequency, duration of illness and lost days of work and/or school

	Number of Households	Percentage [%]	Average Frequency of Illness [times/month]	Average Duration of Illness [days/month]	Average Lost Days, work and school [days/month]
Families with Stomach Diseases	24	64.86	0.99	2.58	1.70
Families without Stomach Diseases	13	35.14	n/a	n/a	n/a

Table 2- Average health expenditure due to waterborne diseases

	Number of Households	Percentage [%]	Average Health Expenditure [Dollars/Illness][3]
Without Health Expenditure	6	25.00	n/a
With Health Expenditure	18	75.00	57.79

As can be seen in Table 2, 25.0% of the families did not report any health expenditure; mostly because their public health insurance covers some of the medicines, others because they use natural herbs to cure themselves, and finally because some families were not able to report an average on health expenditure.

With reference to the most important uses that are attributed to water, 73.0% of the families agreed with the fact that human consumption (drinking and cooking) is the most important use for water. Additionally, 27.0% of the families stated that both (human consumption and irrigation) are equally important and necessary. Finally, 100.0% of the interviewed families affirmed that water is fundamental for their daily life.

[3] Daily Conversion rate taken from http://www.xe.com/es/currencyconverter/convert/?Amount=182&From=PEN&To=USD. Retrieved on March 2, 2015.

5.2.2 Technology-related Issues

Regarding the BWM (the water purifier that was implemented in the school in 2010), only four families (10.8%) mentioned that they remember the device (Figure 10). Among the comments obtained from the families that know the BWM state that is "good" but it requires too much time to produce a minimum volume of water. However, one family said that it was very good, easy to use, it did not require too much strength and it produced enough water. In relation to the question on why the BWM is not currently being used, the comments obtained varied from the fact that it is not practical, also because it is broken, due to the lack of knowledge to use it and finally one family did not know why is currently not working. Additionally, two families mentioned that they would like to see it working again and one family claimed that they would prefer another (more practical) purifying device.

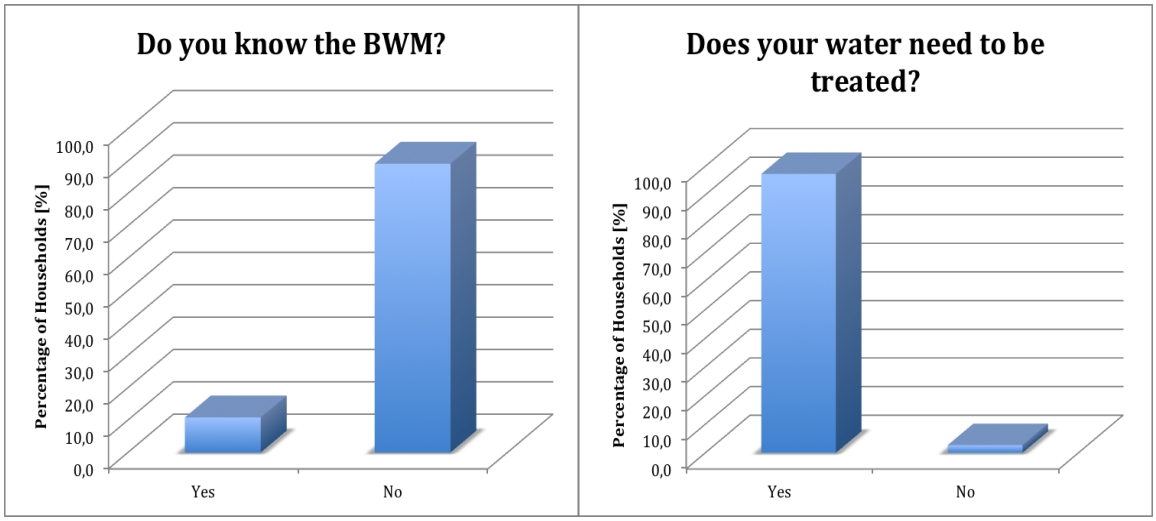

Figure 10 Households familiar with the BWM and necessity of purifying Cuncani's water

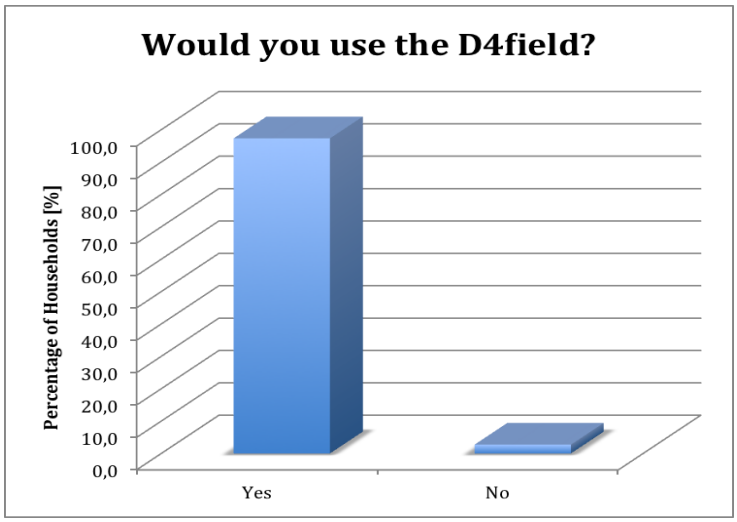

Figure 11 Households interested in using the D4field

On the other hand, when it comes to the necessity of purifying Cuncani's water, 97.3 % of the families agreed with the fact that their water shall be purified (Figure 10). Additionally, it is relevant to highlight that before mentioning and showing the D4field, most of the families said that they think chlorine is the best way to treat water although they are not satisfied with

this method because of the use of a chemical that can affect their health; however, after showing a different treatment alternative they were quite enthusiastic about it, mainly because it would be a more natural and cleaner alternative to treat water in comparison with chlorine. Therefore, 97.3% of the families showed their approval to the D4field and moreover they showed interest in having this purifier in their households instead of chlorine (Figure 11).

5.2.3 JASS and Water Management Elements

In regard to the water management board (JASS) 78.4% of the families know the JASS from Cuncani (Figure 12). However, as observed in the same figure, 55.2% of the families are not satisfied with their work, yet 24.1% of the families are satisfied with their work and finally, 13.8% of the families are moderately satisfied and finally, 6.9% of the families did not provide any opinion because although they know the JASS, they are not familiar with their work. Some elements that were mentioned regarding the JASS improvement opportunities are their responsibility in terms of providing the right chlorine dosage in water, the lack of coordination among its members and the lack of monitoring and maintenance of the water infrastructure.

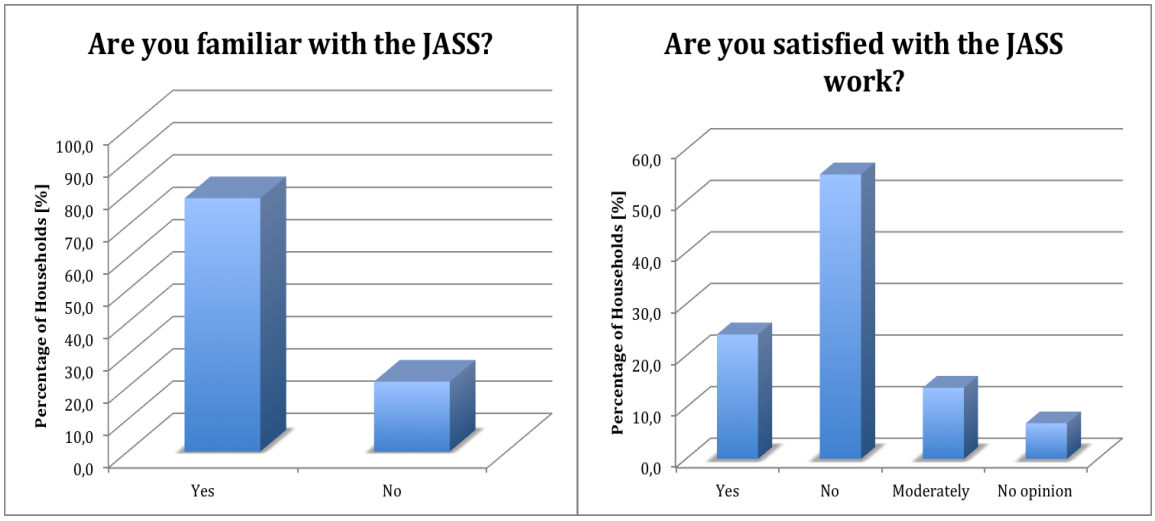

Figure 12 Households familiar with the JASS and satisfaction with their work

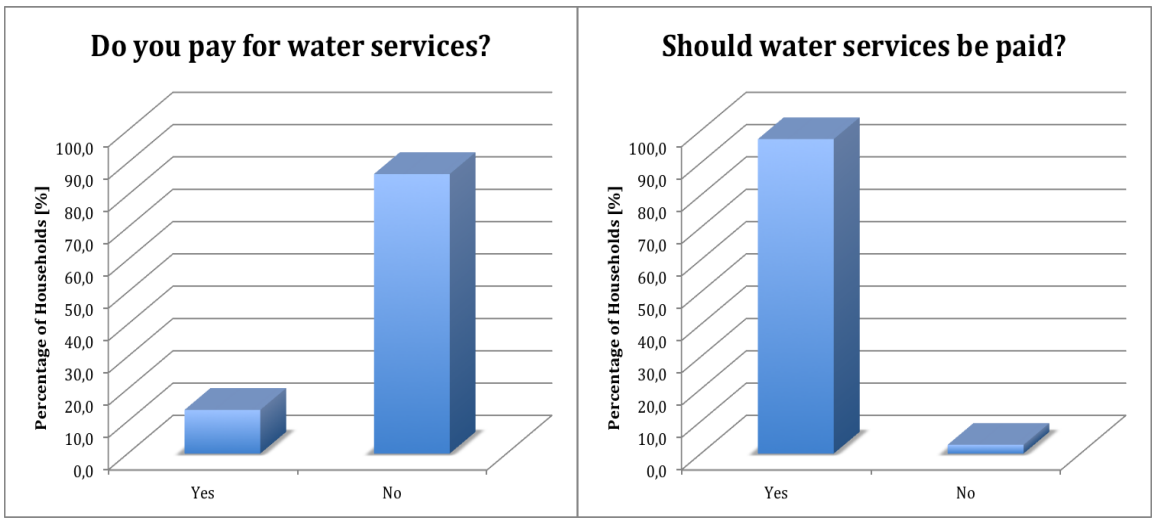

Figure 13 Payment for water services to the JASS and willingness to pay for water services

On the other hand, 13.5% of the families are currently paying a monthly fee to the JASS members (approximately 0.66 Dollars/month). The rest of the families mentioned that they have stopped paying this fee because they are not satisfied with their services (Figure 13).

Finally, 97.3% of the families stated that they would definitely pay for water services as long as these are efficient and with purified water; these families also agreed with being willing to participate in training programs to improve their health and water conditions in their community (Figure 13). However, it was mentioned that they have not received any training programs from the Municipality or from the Lares Health Center. In this regard, people agreed with the fact that they the only ones that receive training programs are the members from the JASS.

5.3 Focus Group Activity

In an attempt to provide the main contributions and the most relevant comments made by each of the stakeholders who attended to the focus group activity, in the following sections a summary of the main contributions will be presented based on the questions intended to be addressed and including agreement and disagreement points among stakeholders. Furthermore, the list of participants for this activity and the format with the questions used can be reviewed on this thesis report within Appendixes I and V.

5.3.1 Factors Constraining the Sustainability of Water Services in Cuncani

Regarding the factors that have constrained Cuncani from having safe and constant water services there was a general agreement on the fact that cultural barriers are a key factor. In this regard, chlorination as the current water treatment method was stated to be a key element in terms of the resilience and opposition that community members have shown against it (E. Rodriguez, personal communication, March 12, 2015). Additionally, it was stated that Cuncani's members perceive chlorine as a chemical that can produce significant health damage and this is why community members have not shown any interest on operating and maintaining their water systems (E. Rodriguez, & S. Sallo, personal communication, March 12, 2015). In addition, in terms of cultural constraints there was also general agreement on the fact that lack of education in terms of proper hygiene practices, lack of training in terms of how to manage their water systems and lack of awareness when it comes to the relationship between water quality and health affectations are fundamental elements which have constrained the proper management of water systems in Cuncani (A. Paz, P. Quispe, E. Rodriguez, & S. Sallo, personal communication, March 12, 2015).

Additional points were raised by some of the participants. For example, the DIRESA worker pointed out that the cultural barrier is also related to the lack of willingness from community members to behave correctly. Moreover, it was mentioned the importance of having community leaders that can help public institutions to promote proper sanitation and hygiene practices directly into the community; this is something that Cuncani lacks of (P. Quispe, personal communication, March 12, 2015). On the other hand, the community member mentioned that there is a general belief among Cuncani's members that if people live in the mountains under certain weather and living conditions, then health issues will always exist. Therefore, community members take for granted that they will be ill and there is not much that can be done (S. Sallo, personal communication, March 12, 2015). Adding to this, one of the NGOs representatives emphasized that perhaps Cuncani's members perceive other necessities before water. Furthermore, it was stated that the need or request of a certain service must come from the community itself; in this regard, it is not enough to have

organizations and/or public institutions providing for something that communities did not ask for (A. Stieglitz, personal communication, March 12, 2015).

Finally, the representative from the Municipality pointed out that there is lack of trust in local authorities and sometimes communities reject their initiatives towards improving their living conditions (E. Rodriguez, personal communication, March 12, 2015). Additionally, a contradiction point was identified from this representative; on the beginning was mentioned that Cuncani's members think that there is no problem on drinking water directly from their faucets (even if water has not been purified with chlorine). However, it was stated later that Cuncani's water is quite pure due to it comes directly from the mountains (underground water). Therefore, it was contradictory to state that water is pure but at the same time people should not drink directly from it without being treated with chlorine.

5.3.2 Chlorination and the Need of Alternative Treatment Methods

This section is intended to address the questions about the effectiveness of chlorine and its acceptance by Cunani's members as well as if the stakeholders believe that there is a need of diversifying the treatment methods used. However, this was a challenging section due to the different arguments presented and contradictions among them.

Regarding chlorination effectiveness the representative from the Municipality stated that chlorination is a good method to treat water. However, later was stated that there is no guarantee of 100% pathogens removal and in contradiction to this, the same person stated that disinfection with chlorine in high dosage should remove all pathogens. The Municipality in this section made an important statement; chlorination method was chose by the Ministry of Health as a guaranteed purification method. However, in the same argument the Municipality acknowledged that they made the mistake of not consulting with the communities before implementing chlorination method in order to evaluate their acceptance to it (E. Rodriguez, personal communication, March 12, 2015). Additionally, the representative from the Lares Health Center stated that an acceptable water quality for human consumption can be obtained through chlorination and in order to obtain a better quality, the current water purification methods can be improved. However, in terms of improvements the representative was referring to the monitoring of water quality, the improvement of the training for members of the JASS and raising awareness among community members (M. Vasquez, personal communication, March 12, 2015). Finally the DIRESA representative stated that the problem is not chlorine itself but people from the communities; changing their culture and their behavior is the hardest thing to do (P. Quispe, personal communication, March 12, 2015).

An important disagreement point was identified when relating to chlorine acceptance from Cuncani's members. In this regard, the Municipality stated that chlorine is not accepted due to the fact that it is a chemical and therefore, people would prefer a more natural treatment method (E. Rodriguez, personal communication, March 12, 2015). However, the Lares Health Center stated that chlorination is accepted by people due to the fact that public authorities have managed to communicate with the community and to explain them the benefits from purified water (M. Vasquez, personal communication, March 12, 2015). To clarify this, the community member pointed out that what normally happens is that while public authorities go to communities and communicate with them, people seem to agree with what they explain in the moment, however, their cultural beliefs go against chlorine (S. Sallo, personal communication, March 12, 2015).

With respect to the need to diversify the water treatment method used, the representative from the Municipality acknowledged that given the results obtained after trying for several years with chlorination method, it would be convenient to start diversifying with alternative methods (E. Rodriguez, personal communication, March 12, 2015). Adding to this, one NGO representative suggested that if people do not truly trust in their water purification systems, it would be convenient to change it and replace it for an alternative method in which the community is actually interested (A. Paz, personal communication, March 12, 2015). Finally, due to the acquire knowledge after the survey carried on in Cuncani within the present thesis work, the community member directly suggested that it would be better to diversify from chlorine using the D4field (S. Sallo, personal communication, March 12, 2015).

On the other hand, the Municipality raised a point in terms of the necessary conditions to diversify their current methods and implementing a different technology. In this regard, was emphasized the fact that communities are used to obtain external support for every problem they have and therefore, they tend to not participate in the maintenance of their own systems. Furthermore, it is important to raise awareness and improve the sense of ownership among people and to make them participate and to contribute with certain fees to maintain their systems (E. Rodriguez, personal communication, March 12, 2015). Finally, adding to this, the DIRESA representative pointed out that people need to assume the responsibility for their own things and change their belief based on the fact the State should pay for everything (P. Quispe, personal communication, March 12, 2015).

5.3.3 Implementing and Maintaining a Technology

Regarding the elements that should be considered when implementing and maintaining a technology in time, it was of general agreement among the different actors that the community plays a fundamental role during both implementation and maintenance of any technology. In this regard, the representative from the Health Center stated that the most important thing is the response from the community in terms of their commitment. However, when it comes to understanding how a technology functions and what are the benefits from it, is fundamental to focus on the education of communities due to the fact that people still do not understand the importance of treating their water. In this sense, the public authorities and organizations need to educate communities in order for them to actually demand for a particular service after they acknowledge the importance of it (M. Vasquez, personal communication, March 12, 2015).

Additionally, cultural factors were mentioned again in relation to the fact that communities are used to get support and infrastructure without actually paying for them. In this regard, a representative from the NGO Alianza Andina mentioned that NGOs unfortunately have a great responsibility of promoting this culture among communities by provide people with free things. On the same line, this representative emphasized that it is fundamental to raise community's sense of ownership; the way in which the NGO Alianza Andina incentivizes people while making them feel responsible for their projects is by providing them with the ideas and the overall project to be developed. However, when it comes to financial resources and participation to develop the project, the NGO only provides them with technical support and very limited financial support. Therefore, both the Municipality and the community are responsible for supplying a significant part of the required materials (A. Stieglitz, personal communication, March 12, 2015).

On the other hand, the participation of the community since the beginning of any project was raised as an important element. In this respect, representatives from the three NGOs who attended to this activity agreed on the fact that is quite difficult to involve the whole

community since the beginning of a project. In case of the NGO Alianza Andina, they offer a certain project to the community within their assembly and normally a limited group of families decide to begin the project; later, more families start joining while they begin to understand and acknowledge the benefits obtained from a project. In this regard, the representative from the NGO ProPeru stated that working with small communities is much easier when a new project is being developed. In case of larger communities, the involvement will be uneven at the beginning of the project (A. Paz, personal communication, March 12, 2015). An additional point was raised by the representative from the NGO Nexos Comunitarios; communication with every community is quite important, not only with the leaders but with the whole community. Moreover, institutionalization is fundamental; in this regard, the unification of the statements and projects planning among the different NGOs and public institutions is necessary. There must be clear communication and coordination among the actors involved to guarantee the sustainability of a project and to promote trust from the communities to their local authorities and organizations (JG. Tarassenko, personal communication, March 12, 2015).

5.3.4 D4field in Practice: Responsibilities and Costs Allocation

For this section, in the hypothetical case of implementing the D4field technology in Cuncani's context, both responsibilities and costs allocation were divided into two fundamental phases of the project: Implementation Phase and O&M Phase. Furthermore, basic tasks or activities for each of these phases were identified in order for the focus group participants could provide their opinion about the actors that should be involved on each one. Figures 14 and 15 will present a scheme with the information gathered for both phases.

5.3.4.1 Implementation Phase

For the implementation phase there was a general agreement on the fact that the community should be involved as facilitator of the purchase itself. However, some disagreements were identified when it comes to the institution that will support them with this. For instance, the community member stated that this task could be done by a community leader together with an NGO; this because it is difficult to work with the Municipality in terms of their time inefficiency and how long they take to actually start with the project (S. Sallo, personal communication, March 12, 2015).

However, after mentioning that a NGO should be involved in this task, the representative from Alianza Andina NGO together with the Health Center representative claimed that the Municipality is the one that should be in charge of this (A. Stieglitz & M. Vasquez, personal communication, March 12, 2015). Finally, the representative from ProPeru NGO suggested that the responsibility should be from both Municipality and community but an NGO could provide some technical or managerial assistance if needed (A. Paz, personal communication, March 12, 2015). Regarding costs allocation and the controversial question of who should pay for the technology (both purchase and installation), the suggestion of both Municipality and community should pay for the technology was agreed among all attendants except for the community member; it was stated that the community can contribute with labor with their people and within the maintenance phase by paying a monthly fee, however, as they do not have a significant amount of cash available, the technology could be paid by the Municipality possibly with the support of an NGO (S. Sallo, personal communication, March 12, 2015).

With respect to the installation of the D4field itself, there was a full agreement on the fact that it should be carried on by the institution with the strongest technical knowledge. However, none of the attendants identified which institution they believe could be suitable for this.

Finally, when it comes to the training of the JASS as the community leaders who will be in charge of the operation and maintenance of water systems from Cuncani, there was a full agreement on the fact that the private company which manufactures the D4field (Watersprint AB) should be in charge of both facilitation and to cover the related training costs; the argument around their responsibility in costs was based on the fact that companies normally include these types of expenses in the final price of the product.

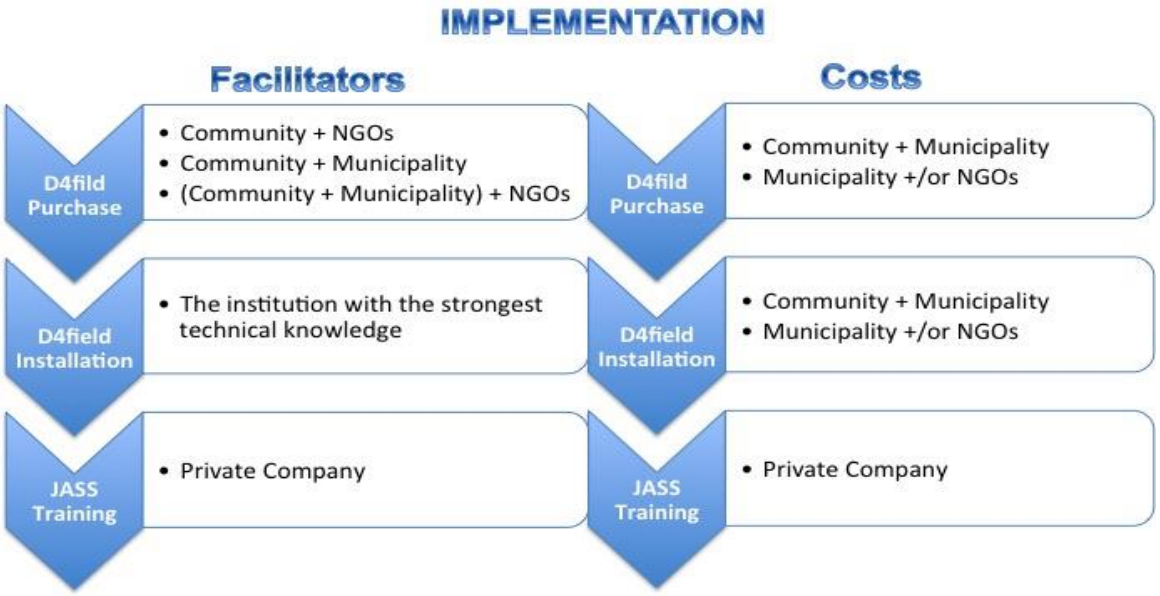

Figure 14 Facilitation and costs allocation for the implementation of the D4field

5.3.4.2 O&M Phase

For the Operation and Maintenance phase there was full agreement in most of the suggestions made by each of the tasks. For example, when it comes to the replacement of broken parts or any required repairs and for the general maintenance as well, all the participants initially suggested without hesitating that the community should be in charge of carried on these activities. The only point that was raised was related to the costs of the broken parts and repairs; in this sense the representative from ProPeru NGO stated that if these costs are too high people will most likely not be willing to pay for them. In this case, the suggestion made was that an external organization (private business or and NGO) might be able to cover these expenses (A. Paz, personal communication, March 12, 2015).

In relation to the monitoring of the water quality, the Ministry of Health is legally in charge of performing any monitoring tests and to cover for the related costs. Moreover, the Ministry normally delegates these responsibilities to the Health Centers that are closer to these types of communities. Therefore, in the case of Cuncani the responsible for the monitoring of water quality is the Lares Health Center. However, the Health Center is only responsible for taking the correspondent water samples periodically and to take them to the DIRESA Laboratory. As stated in the Interviews section, if there are any issues with water quality, both Health Center and Municipality should be notified so they can take corrective measures.

Finally, in regard to the training to the community (hygiene and health-related education), there was general agreement on the fact that the Health Center is legally responsible to cover for the related costs. However, when it comes to the facilitation itself, both Municipality and Health Center representatives stated that this is a joint responsibility among them. However,

representatives from two NGOs suggested that this task should be also facilitated by the institution in which communities trust the most; in this sense, it was mentioned that public institutions can and should have support from the NGOs that might have knowledge in the subject and more and better relations with community members (A. Paz & JG. Tarassenko, personal communication, March 12, 2015).

Figure 15 Facilitation and costs allocation for the operation & maintenance of the D4field

5.3.5 The JASS and its Role within Water Services

When relating to the JASS group and their role within water services and in the implementation and maintenance of a technology, there was a general agreement on the fact that they should participate in the different phases of the service provision. For instance, an NGO representative mentioned that the JASS ideally should be part of the training programs developed so they can acquire the knowledge for the implementation and the maintenance of a technology (JG. Tarassenko, personal communication, March 12, 2015). On the other hand, besides the monitoring responsibilities, the representative from the Municipality stated that they should also serve as facilitators within the community in order to enhance the communication with their local authorities and institutions to inform them about any issues related to their water systems; in this way would be much easier to provide support to the communities whenever they need it (E. Rodriguez, personal communication, March 12, 2015).

An important discussion point was raised around the payment for JASS services by the community. In this regard, going with the baseline established by National legislation in which it is acknowledged the responsibility from the community when it comes to the payment for the services provided by the JASS members, the representative from the Municipality pointed out that communities are able to pay to sustain the JASS activities with a monthly fee; it was said that communities do have financial resources to cover these expenses (E. Rodriguez, personal communication, March 12, 2015). However, the community member claimed that although the families have assets such as animals and land, their income is quite unstable and they do not have a sufficient amount of cash available. Additionally, families have expenses related to food, education, among others and families can barely cope with these expenses (S. Sallo, personal communication, March 12, 2015). In addition to the points raised, the Lares

Health Center representative emphasized that besides the financial resources issue, it is also matter of the value the community puts into certain services; even by paying a small fee, it is matter of their lack of willingness to do it and their lack of knowledge to recognize the importance of it (M. Vasquez, personal communication, March 12, 2015).

5.3.6 Perceived Benefits of the D4field

If the D4field is to be implemented and sustainably maintained on time, the direct and indirect benefits would cover different levels of actors and institutions, from the community itself to the Municipality, Health Center, and NGOs, among others. In this regard, there was a general agreement on the following benefits:

- ✓ Improving health of community members, not only on directly related waterborne diseases but in malnutrition as well.
- ✓ Reducing health expenditure from both community members and related institutions; in this regard, it was stated that if health expenditure from a certain community is reduced then public institutions can invest more in other communities and/or new projects; this in terms of financial resources as well as time resources.
- ✓ As health is a pillar towards development, improvements on health will help communities to enhance their own development.
- ✓ People will experience and perceive the long-term benefits from improved health.
- ✓ If the implementation is to be sustainable in Cuncani, this community can be a pilot for the expansion on the implementation of the D4field into other communities.
- ✓ The implementation project of a technology might help to improve communication and coordination among different institutions and organizations.

5.4 Additional Findings

Although water quality status from Cuncani was not to be determined on the present research, an additional research process was carried on in order to verify the actual scheme in which public institutions work regarding water quality monitoring in rural communities. In this regard, three public institutions were contacted in order to obtain the most recent results of the water tests that are to be carried out in every community. The Municipality of Urubamba, the Lares Health Center and the Laboratory from the Ministry of Health or DIRESA were visited and the correspondent representatives were reached. However, after several attempts to obtain the results from the water tests done in Cuncani, the present research work was not able to obtain this information. The apparent reason for this was not related to the lack of willingness from the representatives from each institution but due to the lack of records on the water tests. Furthermore, it was not possible to determine if the lack of records was due to the inexistence of the water tests in Cuncani (which would mean that no water samples were taken by the Lares Health Center) or if the records with this information were lost after performing the tests.

On the other hand, a representative from the Lares Health Center was reached in an attempt to determine the current expenditure from this Health Center and the related Health Ministry when it comes to waterborne diseases and furthermore, with the intention to verify how many people from Cuncani actually attend to the Health Center when having stomach illnesses and therefore, to enhance understanding on the value that is given to health by community members. However, after several attempts to obtain this information, lack of willingness to provide it was a limitation for the present research work.

6 Analysis and Discussion

In the present chapter the author presents an analysis of the previous findings based on the theoretical water resources management principles that were introduced in Chapter 3 and on the theoretical factors related to sustainability of a service that were introduced in Chapter 4.

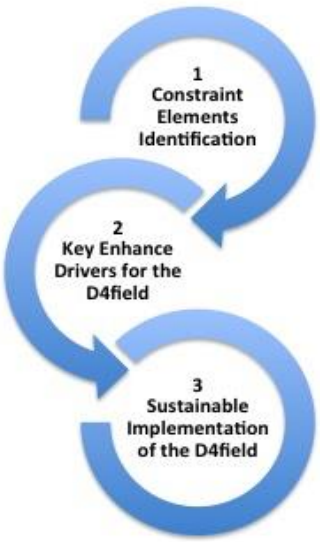

Figure 16 Analysis Outline

The rationale for the outline in which the analysis is presented is based on three key stages towards the disclosure of the aims and research questions of the present thesis work. The first stage is related to the identification of the constraint elements for a safe water supply in Cuncani based on the functioning of the current water services and related actors in this community. The second stage is related to the possible solutions and the key drivers that could enhance the enabling environment so the D4field technology could be implemented in the first place; this is based on the comparative analysis of the findings and the previously mentioned theoretical principles. Finally, the third stage is related to the sustainable implementation and maintenance of the D4field and the institutional scheme that could fit this technology; this is based on a comparative analysis of the findings from the focus group and the theoretical principles related to sustainability of a service (Figure 16).

6.1 Current Water Services in Cuncani

This section will be divided into three sub-sections in order to first provide an understanding on the overall situation around water services in Cuncani. Secondly, to provide more details on how water services work in the practical level and finally, to grasp key lessons based on the implementation failure of the BWM device.

6.1.1 The Big Picture

Participation as a fundamental element when developing a water-related project

Although Peruvian legislation places a strong focus on communities and their role in the management, operation and maintenance of their water systems, in reality participation from communities is actually not given within the whole project cycle (from the design to the implementation and maintenance). Since major decisions regarding water infrastructure and the convenient purification methods are made within National level and then established as directives so the Regional and Municipal levels follow these instructions, communities are not actually involved within the design phase of their water systems but only have the possibility to participate within O&M activities.

Contextualization of water systems and related regulatory frameworks and institutional arrangements

Following up the participation principle, as acknowledged by the representative from the Municipality of Urubamba, the first drawback of the current water system and the related purification method based on chlorination is the fact that the design of these were carried on in the National level by the Ministry of Health regardless of local conditions. Therefore,

elements such as actual demand for a service, cultural beliefs and convenience from communities were not considered when implementing the current chlorination system.

Although regulatory frameworks can be defined by each JASS from the different communities, these are to be developed after a certain water system is installed. Furthermore, in case of Cuncani, since chlorine is not culturally accepted by community members, the author infers that the contextualization principle was not considered when designing their water systems. In addition to this, elements such as lack of interest and willingness to properly manage and maintain their systems, lack of willingness to pay to their JASS members to develop maintenance tasks and the lack of trust from community members in the water quality from their systems can be attributed to the strong cultural beliefs which are not align with their current water system. The present research study was able to confirm this fact by interviewing community members in the survey activity; in this regard, most households showed their dissatisfaction with chlorine due to its possible health affectations and furthermore, as UV light is to be a more natural water treatment method with no chemicals involved, the D4field technology had a remarkable acceptance due to its alignment with the community's cultural beliefs.

Effective regulatory frameworks and institutional arrangements as requirements to achieving sustainable management of water resources

As for Peruvian legislation the decentralization approach is the baseline principle to improve the effectiveness of water services and a strong focus is placed in Municipalities, local authorities and their relationship with the JASS from communities; however, when it comes to the Water and Basic Sanitation Office from the Municipality of Urubamba and the Lares Health Ccnter, important limitations were highlighted as constraint elements for the effectiveness on water services provision in the surrounding communities. In this regard, elements such as lack of qualified personnel due to the constant rotation from them, the lack of political will from higher authority levels to provide financial and human resources so offices such as Water and Basic Sanitation can properly perform their tasks, lack of communication and lack of trust between public authorities and communities, are among the most important elements identified by the present thesis work; these are constraining the effectiveness on the institutional arrangements currently in place and therefore, the support that these institutions are able to provide to communities is fairly limited.

Additionally, when it comes to the dynamic between the relevant actors for water services provision, from personal observations during the focus group activity and also from the information provided by NGO members, there is a fairly obvious disintegration and lack of coordination among institutions. Although National legislation establishes the different responsibilities attributed for each actor (including communities and their JASS), given the lack of communication and coordination among institutions, in practice the author perceived an unclear arrangement and responsibilities distribution.

Water governance initiatives should start on the local level & Water systems should be managed not only from the supply-side but from the demand-side as well

Even though water access initiatives actually started at the community level (given that Cuncani members demanded for water access to the Municipality of Urubamba and because of that in 2010 water systems were installed), the author perceives that demand for improved water services is still not strong enough to achieve a change. In this sense, the present research proved through the survey that people belief in the importance of drinking water for their daily activities and also in the need on purifying their drinking water. However, in spite of the

dissatisfaction with chlorine, so far there have not been any tangible initiatives from the community to search for alternatives and to demand for a different purification system. Instead, a strong resilience to maintaining chlorination system has been promoted without seeking for an improvement in this method by the replacement with an alternative one.

An important remark to this point is the actual priority that is given to water quality and the lack of knowledge regarding its relationship with health; in relation to this, this thesis proved that there is a fairly low understanding among community members on the fact that their stomach illnesses might be strongly related to the fact that their water is not being properly purified. Therefore, given their lack of understanding on this subject, the demand for improved water services will continue to be fairly low.

In addition, two possible elements contributing to the lack of demand for improved water services were identified. The first one was brought up by most of the interviewees during this research; lack of information retention by community members seems to be an important element to consider. In this sense, public authorities and NGOs claimed to participate in educational programs to promote water, hygiene and sanitation practices and in spite of this, after a certain period of time community members tend to forget the information that was given to them. However, although the scope for this thesis did not consider elucidating the complexity of this issue, the author considers that elements such as lack of interest combined with their possible physical inability to retain knowledge due to malnutrition issues could be some of the causes of the community's lack of knowledge retention. Similarly, an important element to consider and that was also brought by different actors is the community's tendency and proven behaviour to expect for external support (mostly from NGOs) to solve any issues that they have and therefore, no initiatives are started from the community itself.

Finally, these principles involve the complexity of both lack of contextualization from the design level of water systems to the actual needs, cultural beliefs and preferences from communities as well as to the lack of a tangible demand for improved water services from Cuncani.

The importance of having effective stakeholder participation and involvement within water management systems

For this point, it can be stated that given all the health affectations due to poor water quality in Cuncani, the ineffectiveness of water systems and furthermore, the ineffectiveness of stakeholders participation are fundamental issues within water systems management. In this regard and as mentioned by representatives from public institutions, ineffectiveness issues start at the National level by transferring all responsibilities from water and sanitation services to the Municipal level (based on the decentralization approach) without providing the resources required to cope with this responsibilities.

The problem of lacking resources and capabilities to guarantee an effective services provision has basically pushed public authorities to rely on organizations such as NGOs to obtain the required support. In relation to this, during the focus group activity, a general complaint from the three NGOs who attended was the fact that some of these organizations are currently struggling to cope with the responsibilities that are theoretically attributed to public authorities. Additionally, from personal observations the author sensed that given the previous experiences between community members and NGOs, members from Cuncani actually trust NGOs in a much higher level than they do with public authorities (both Municipality and Health Center).

Therefore, the combination of lacking trust, resources and capabilities makes stakeholders participation in Cuncani by far difficult to reach an effective level in which every stakeholder can assume its own responsibilities and cope with them without interfering with the others. In addition to this, the present thesis research infers that given the weakness on the public institutions to cope with their own responsibilities, an entrepreneurial initiative might boost and improve the management of water systems in communities such as Cuncani. However, given the current disaggregation among actors currently participating in the provision of water services, it could represent a great challenge for a private business or entrepreneur to support these activities without a clear, concise and enforced regulatory framework and without effective participation of public institutions. Furthermore, as stated by the representative from the Municipality of Urubamba, the possibility of private-public partnerships will rely on the willingness to pay from communities for improved water services.

Strengthening gender participation and empowering women to enhance sustainability of water systems

For this principle, in case of Cuncani and in most of rural communities close to it, there is still a strong male chauvinism and therefore only men are in charge of doing activities in their land, tourism (during the particular tourism season), among others, while women are to be always at home taking care of household activities (including looking after their children). In addition to this, from personal observations during a monthly assembly in Cuncani the author was able to observe the community dynamics and discussions (although in Quechua dialect). From these observations, was evident that women participation in these types of community meetings is fairly low and most attendants to the assembly and the ones involved in making community decisions are mostly men.

Therefore, contrary to all the suggestions made by the different authors in Chapters 3 and 4 of the present research work, social conditions together with cultural beliefs and behaviour in Cuncani regarding women participation are still undermining their potential to perform the role as community members with the right to also make decisions when it comes to water systems according to their preferences and needs.

There is a strong linkage between effective water governance and poverty alleviation

As for this principle, the present thesis work proved that there is a linkage between waterborne diseases, health and therefore education and work-related activities. In case of Cuncani, from the households that affirmed getting ill over stomach-related diseases, there is an average of 2.58 days per month in which people are ill and the actual tangible consequences in terms of less productive days (whether on school or work) is of 1.70 days per month lost. However, it is also important to highlight that even if attendance to school or to work activities does not actually reflects the days in which people are sick, the author also infers that while suffering from stomach-related diseases, productivity during work or school days will be affected by health elements.

Furthermore, although outside of the scope from the present research work, malnutrition is a subject that is directly related with waterborne diseases as well (as stated by the representative from Lares Health Center) and that is currently affecting to Cuncani's members (Nexos Comunitarios, 2012). Basically, even if people eat food with all the required nutrients, if they use contaminated water to clean their food and to cook, they will also ingest all pathogens within water and similarly suffer from waterborne affectations. Therefore, this thesis can state that water might be one of the sources of health issues that are contributing to Cuncani's vicious poverty cycle.

Promoting training and education is fundamental to enhance sustainability of water services

When it comes to knowledge and capacities from the design phase of a water project to the operation and maintenance phases, this thesis was able to prove how representatives from the Municipality do not have a clear understanding on the current water purification systems that are in place. In this regard, as previously showed, an important contradiction was found between the statements made by the Municipality representative and the Lares Health Center representative when it comes to chlorination effectiveness for pathogens removal. In relation to this, training and education programs are to be implemented in different institutional levels if a decentralization approach is to be implemented. It is not only matter of training and educating community members about water, sanitation and its related health and growth benefits, but also building capacities among the local authorities that are in charge of water services provision.

Promoting a payment culture among community members before implementing any water-related systems

This is an important element that was studied during the present research. According to the surveys developed in Cuncani, community members are willing to pay for improved water services as long as these are effective. However, when it comes to reality, during the focus group, this thesis was able to verify the fact that the community lack of actual cash to perform significant payments for infrastructure (technologies) and/or operation and maintenance services. Nonetheless, most of stakeholders claimed that there is not actual lack of cash but lack of willingness to pay from people of direct and tangible benefits are not perceived. As stated by the representative from Buen Power Company, people invest in their energy-related products because they perceive a direct and immediate benefit.

An additional element of relevance that might be interfering with the development of a payment culture among community members is the fact that they have been able to obtain a significant amount of benefits (infrastructure, food, medicines, among others) without actually paying for them. Most of the stakeholders that participated in both interviews and focus group activity pointed out this as an important element that is constraining the community's long-term vision and similarly their willingness to pay and/or to develop initiatives to solve community issues. Therefore, this thesis concludes that the lack of a payment culture regarding improved water services will represent a challenge for both public institutions and entrepreneurs or private businesses that are eager on participate in water projects in Cuncani.

Developing a monitoring system for both resources and people's behavior

Regarding monitoring systems, this research work proved the difficulties when it comes to accessing information related to water quality in Cuncani. In this regard, as mentioned previously, if water tests are not being performed or results are not correspondingly reported to the relevant institutions, this proves that monitoring systems are weak in different institutional levels. Theoretically, Peruvian legislation establishes that water quality assurance is a fundamental responsibility of the Ministry of Health through their Regional agencies (DIRESA). Furthermore, the Ministry of Health can monitor through Regional agencies not only water quality to determine the current state of water resources but also to monitor health consequences from poor water quality. Therefore, this research infers that the lack of coordination among the different actors involved within monitoring systems is making these systems weak and ineffective to manage both water resources and people's health.

An additional point that is to be highlighted is the monitoring system from the Municipality to the community's water systems. It was highlighted by the representative from the Municipality

that due to lack of financial resources and because of the constant rotation of personnel within the Water and Basic Sanitation Office, monitoring tasks are fairly difficult to carry on. Together with this, it was also pointed out that representatives from the JASS in Cuncani do not attend to the regular meetings that the Municipality carries on with all the JASS from different communities. Therefore, monitoring activities in Cuncani are also an important weakness element from the whole water system's perspective.

6.1.2 The Operational Level

In this section, some practical elements regarding services provision and related sustainability are to be highlighted when it comes to the current water and chlorination system in Cuncani.

As previously stated, the Municipality has delegated the responsibility of managing water systems in all communities under their jurisdiction to the JASS or water management boards from each community. Furthermore, as reviewed in Chapter 4, authors place a strong importance on the existence of effective water committees in order to guarantee the sustainability of water services provision. However, the present research work proved that the JASS from Cuncani is not actually performing their tasks when it comes to managing water systems. Moreover, although the current directive or group members are known by a significant part of the households that were interviewed (78.4%), most of them are not satisfied (55.2%) or moderately satisfied (13.8%) with the JASS's performance and, this is one of the reasons why households are not currently paying for their services.

This thesis deduces that all of the above-mentioned elements can be part of a vicious cycle among the JASS's lack of capabilities and time to perform a work which is actually not being paid, the lack of interest and responsibility among community members to demand for improved water services and the lack of willingness to cooperate with the JASS and to pay them for their services and finally, the lack of monitoring from the Municipality given that the JASS as institutional actor involved in water systems management is obviously failing to meet its responsibilities and the sustainability of water services in Cuncani is being constrained by this.

Another important element is the lack of enforcement from public authorities to promote the effective functioning of the JASS. In this sense, the Municipality is not to establish the monthly fee that households shall pay given that National legislation establishes that monthly fees should be agreed among community members during their assemblies. However, Municipalities and specifically the Water and Basic Sanitation Office have the responsibility of monitoring and assuring the effective services provision within communities. Finally, within monitoring activities, Municipalities have the responsibility of providing training and education programs for both community and for the JASS members so they can perform effectively their tasks. Nevertheless, it was of great difficulty for this research work to determine the degree of lack of responsibility between the Municipality and the JASS members; given that all the information was provided by personal statements made by different stakeholders, it was not possible to determine whether the Municipality is not carrying on training programs to the JASS members or if the JASS from Cuncani is not attending to these programs.

On the other hand, a fundamental issue that was assessed during this thesis is the community's knowledge on the relationship between water quality and health. In relation to this, the present research showed that only 45.8% of the households that currently suffer from stomach-related affectations understand the fact that as their water might has contamination problems, therefore they are suffering from waterborne diseases. This is a remarkable fact due

to its strongly possible relation with the lack of demand for improved water services in Cuncani. As stated in Chapter 4, in order to enhance the sustainability of water services it is fundamental to educate people towards the understanding of the importance of water quality and their health.

6.1.3 Key Lessons from the Failure of the Better Water Maker

The implementation and later failure of the Better Water Maker (BWM) device in Cuncani is a relevant example of how a technology can be unsuccessful in a community even though it is actually aligned with cultural beliefs of people, given that this device also works with UV light as water purification method. As this technology was not actually demanded by people but implemented by an external actor, no sense of ownership was promoted among community members. Indeed, this research proved that the BWM is not currently in use and furthermore, only 10.8% of the households were actually familiar with it.

From the implementation of the BWM and the theoretical factors involved in the sustainability of a water system, some elements were identified by this thesis as key lessons for future technological implementations in Cuncani:

- ✓ Lack of contextualization and the understanding of the community's needs, preferences and its current social structure can undermine the success of any technology.

- ✓ Coordination, communication and engagement between the entrepreneur and the actors in place is fundamental, given that the manufacturer of the BWM lost contact with the NGO with whom they created the partnership to implement the technology. Furthermore, the entrepreneur did not have any contact with local authorities or any understanding on the functioning of the JASS in Cuncani. Therefore, monitoring activities were not given after the device was donated to the school in the community.

- ✓ As the entrepreneur gave no direct training to the community or to the NGO in charge of the implementation, future maintenance and repair tasks were hindered.

- ✓ As the community did not have to pay for this technology itself, this might have promoted the lack of sense of ownership and a low interest to maintain it.

- ✓ Due to the lack of demand for a service coming from the community and the correspondent sense of ownership, no community arrangements were placed in order to support the operation, maintenance and monitoring of the technology. Hence, promoting its inevitable failure.

- ✓ Technical and practical details of the device are important when it comes to promote acceptation from people. In the case of the BWM, elements such as convenience in time, amount of clean water produced and the requirement of physical strength to produce the water were mentioned as disadvantageous.

6.2 Setting the Enabling Environment for the D4field

If the implementation of the D4field is to be successful and sustainable in time, the present thesis work emphasizes the fundamental elements that need to be improved in order to set the enabling environment for the implementation of this technology.

- ✓ Focusing on educating people as a mean towards raising awareness and instilling a payment culture for sustainable services. On the same line, the importance on raising awareness and improve education and training among JASS members so they can acknowledge their fundamental role as community leaders, communicators between the community and local authorities and furthermore, as innovators and disseminators of technologies.

- ✓ The encouragement of participation from entrepreneurs and private businesses is also an important issue if Watersprint AB is to participate in the water services provision through the D4field. Although National Legislation through the Decree No. 1012 (2008) sets the legal framework in which private businesses are encouraged to participate and to create Public-Private Partnerships, in reality this thesis found that there is no tangible experience in Cuncani between the private and the public sector when it comes to services provision at the Municipal level for rural areas. This fact is also supported by the *Instituto Mexicano de Tecnologías del Agua* (IMTA) and the OECD (2008), stating that private participation within rural services provision in Peru has been delayed, with no tangible results and furthermore, with a stronger focus on urban areas. As also stated by the representative from Buen Power Company, even though they have tried to work together and to collaborate with local governments, their political will is still a constraining element.

- ✓ An additional point goes in line with the importance of not only encouraging entrepreneurs participation into services provision, but also entrepreneurs that are innovating towards environmental sustainability; as stated in Chapter 4, environmental aspects are crucial in the sustainability of a service. Furthermore, as Peruvian legislation acknowledges the importance of protecting natural resources and of achieving the MDGs, hence this thesis suggests that strong priority should be given to the deployment of markets for technologies that are conveniently adapted to fulfill people's needs while protecting the environment.

- ✓ As mentioned previously, there should be a strong focus placed on improving communication, cohesion and coordination among actors. If the D4field is to be sustained in time, there is a necessary involvement and responsibilities allocation among actors, and these are to be performed in an articulated manner within the most convenient institutional arrangement. In addition, as stated in Chapter 5, section 5.3.6, the implementation of the D4field could work as a pilot project to improve collaboration among different actors and institutions.

On the other hand, acknowledging the statements from the focus group activity and in concordance with the adoption theory for technological innovation by Rogers (1995), this thesis emphasizes that even if the above-mentioned elements are in place, the technological adoption will first be given by a determined part of the community (early adopters) and later, while having tangible and observable benefits, other households might adopt the technology as well (late adopters). As mentioned in Chapter 5, starting a project with the whole community from the beginning is not realistic; some households will join from the beginning and they are expected to start the dissemination process by communicating to the rest of the community their experiences with the technology.

Additionally, based on the results from the survey in the community, this thesis suggests two possible scenarios for the implementation of the D4field. The first one might be starting with the portion of the households who besides acknowledging suffering from stomach-related illnesses, they actually relate them with water quality issues (45.8%); this will mean that their main motivation might come from the intrinsic knowledge of the relationship between water quality and health and their possible initiative to improve their health conditions. The other scenario might be to start implementing the technology with the households who besides

acknowledging suffering from stomach-related diseases, they actually have a health related expenditure (75%). In this case, the motivation will be related to the tangible benefit of the reduction of their health expenditure besides improvements in health. A combination of both groups might also be convenient; however, this thesis found that not all households who acknowledge the relationship between water quality and health actually have health expenditures (due to the reasons mentioned in Chapter 5) as well as not all households that have health expenditures are aware of the relationship between their illnesses and water quality.

6.3 Reflections on the Implementation and Maintenance of the D4field

Under the hypothetical scenario in which the D4field is to be implemented in Cuncani on 'ideal' socio-economic, cultural and political conditions, the coming issue is related to the institutional scheme that would fit this technology. Therefore, considering the relevant actors such as Municipality of Urubamba, Lares Health Center, NGOs, Private Company (Watersprint AB) and the Community; following the statements presented by the different actors in comparison with the theoretical sustainability principles introduced in Chapter 4, this thesis intends to enhance knowledge on the key actors and theirs roles in the implementation and long-term sustainability of the D4field.

6.3.1 Municipality of Urubamba

The Municipality of Urubamba plays a key role when it comes to water services provision. Therefore, as for any improvements within water systems in Cuncani, there are different roles in which its participation is crucial. There was a general agreement among different actors on the fact that the Municipality shall be involved when it comes to the purchasing and installing the D4field. In this sense, as National legislation places into Municipalities the responsibility of providing the required infrastructure for services provision within their territorial jurisdiction, thus this institution has a significant share of the responsibility of both facilitating and affording the water purification devices required for the provision of a safe drinking water supply.

A controversy point that was found in the present thesis research as well as in the reviewed literature relates to the most effective and fair cost-sharing division between the Municipality and the community when it comes to the initial investment and the purchase itself of a particular technology. Based on the statements made by most actors (excluding the community representative), even though the Municipality would have a strong share of the payment of the D4field, the community would also play a crucial role by contributing with this investment; this goes in the same line with the statement from Whittington et al (2008) in Chapter 4 suggesting the requirement of communities paying for at least a part of the investment costs. Nonetheless, this thesis acknowledges that even with a low share from communities within the cost-sharing division with the Municipality, considering their financial conditions, this will represent an enormous effort from the community. Hence, the author infers that this effort would be translated into a great sense of ownership and responsibility to maintain their investment. On the other hand, even on the basis that a community such as Cuncani would need external support to afford a technology like the D4field, as National legislation places the strong focus on Municipalities, no other schemes for external support were suggested; for example, having an external donor (besides the Municipality) contributing with water quality improvements in rural communities.

Although the Health Centers are legally responsible for this, another important responsibility that was attributed to the Municipality is related to the participation on the development of permanent training programs to the JASS and also to the community in relation to water, sanitation and hygiene practices within households; which goes in the same line of arguments regarding support, training and education from public authorities presented in Chapter 4. Additionally, if a Private Company is to directly or indirectly participate in the services provision, the Municipality has the important responsibility of enforcing the regulatory framework set at the National level in which this participation is given. Moreover, as public institution in charge of guaranteeing the proper and fair provision of a service, the Municipality is a key actor in the permanent monitoring of these services and the related actors involved.

6.3.2 Lares Health Center

When it comes to the Health Center responsibilities, the present thesis confirmed the statements made in Chapter 4 which suggest that top-down approaches are required in order to properly monitor quality and quantity of a water service; in this sense, all actors agreed on this fundamental task which is actually a joint responsibility from the National level (through the Ministry of Health), the Regional level (through the DIRESA and its Water Laboratory) and the Local level through Health Centers.

Additionally, as previously mentioned, the Health Center is the public institution with the strongest responsibility on educating people when it comes to water, sanitation and hygiene; which relating to this thesis is fundamental given the low awareness of people regarding water quality and health. Therefore, this institution is to promote the knowledge foundation so people can demand for proper water services.

6.3.3 Non-Governmental Organizations

Under the hypothetical and legally appropriate scenario that public institutions comply with their responsibilities, NGOs could come into the water services provision scheme as possible partners of both private businesses and local authorities. As from personal observations from the author and in regard to the statements made around the trust that communities have placed in NGOs, these organizations actually have a tremendous knowledge and practical experience that could be shared with public institutional and private businesses or entrepreneurs.

In case of the D4field implementation and maintenance, this research work showed the general agreement on the fact that NGOs could perform the role of facilitators of different processes. For example, if NGOs have the technical knowledge, it was suggested that they could participate as facilitators in the purchase and installation of the D4field; this would be aligned with the theory stating that partnerships with local authorities and private businesses could be created to facilitate determined tasks in water services provision. Additionally, for the monitoring phase of water systems, given the knowledge and acquired experience from their work with communities, NGOs could also work as facilitators within training and education programs in communities.

6.3.4 Entrepreneurs (Watersprint AB)

According to the different actors, besides their fundamental role as technology providers, another role that is attributed to Watersprint AB when it comes to the implementation of the D4field is the training that must be provided after the purchase so the device could be

successfully installed, operated and maintained (in case of any particular maintenance procedure). As the responsible for the operation and maintenance in the JASS, thus this training must be carried on with this management board.

Additionally, even though there was a general agreement on the fact that the community should be in charge of general maintenance and repairs (if necessary), given the previous experiences with both chlorination system and the BWM device, this thesis suggests that for the repairs and general monitoring, could be convenient to have the private company participating on this. If it is not possible for Watersprint AB to directly participate in these tasks, given that the company has its internationally central location, then strategic partnerships might be created with for example an NGO and/or a local entrepreneur; this in order to guarantee the existence of the technical knowledge to provide the required support. However, the proper costs distribution in this case will depend on the institution in which responsibilities are outsourced. In case of an NGO, as they are legally recognized as non-profit organizations and they have limited budgets for their projects, Watersprint AB would be key on the provision of the required financial resources in order for them to perform maintenance and operation tasks. On the contrary, if a local private company assumes these responsibilities, depending on the willingness to pay from the community monthly fees might be established to cover these costs.

6.3.5 Community and the Water Management Board (JASS)

As the main beneficiary of improved water services, the community plays a crucial role by participating during the whole project cycle. Through interviews, a survey and a focus group, the present thesis research verified that the statements made by different actors are fairly in concordance with the sustainability principles reviewed in Chapter 4 when it comes to community participation.

As suggested by relevant actors, investment costs related to the D4field are to be shared between the Municipality (with the highest share) and the community (with the lowest share). However, as determining the most convenient share was not to be covered within this thesis, the author recommends having communication between both actors in order to determine the most convenient and fair share. As confirmed by the community representative, communities normally lack of cash and/or have a quite unstable income; therefore, this is a fundamental element that needs to be considered by the Municipality.

Regarding operation and maintenance of water systems (including the D4field), the JASS is to play a fundamental role as community leaders in charge of guaranteeing proper services provision within the community. As also mentioned by most of the authors in Chapter 4, this research agrees on the responsibility from communities by being in charge of the operation and maintenance of their water systems in order to promote sustainability of water services. It is also important to highlight that communities are the central actor in terms of decision-making; this means that besides agreeing in the establishment of monthly fees, communities are to actively participate in deciding the convenient participation in their services provision. In this case, if external support is needed (from a private company or an NGO), communities would play a leading role in promoting initiatives and sense of self-diligence towards pursuing this support. Finally, commitment from communities is an important element when managing their water systems; both JASS and community members are crucial participants in every training and educational program. Efforts from the Municipality and the Health Center would be ineffective if communities are not fully committed to cooperate with them.

6.4 Additional Remarks

6.4.1 Safe Water without Proper Hygiene Practices?

Although the hygiene component of the water and sanitation issues was outside the scope of the present research work. As also emphasized in Chapter 4, the author acknowledges the fundamental importance on the relationship between having safe water and applying proper hygiene practices at the household level. Acknowledging the influence from proper hygiene practices on people's health is a basic principle if a holistic approach of the water and sanitation problematic is to be applied.

In the case of Cuncani, for future research the author recommends to determine the exact properties related to water quality in order to enhance the understanding on the actual influence from both water quality and hygiene variables have on people's health. Furthermore, it is fundamental to acknowledge that even if a technology such as the D4field is to be implemented and water quality reaches the healthiest possible level, if this initiative is not accompanied with proper hygiene practices at a household level, benefits from these efforts will not be completely acknowledged as the perceived health outcomes will not reach the expected ones.

6.4.2 Sensitivity Analysis

The perception of what being 'healthy' means can have a fairly strong relevance when carrying on activities such as surveys in a community. In this case, the author perceived that when carrying on a survey and asking a question related to the most common illnesses and just by asking if people get ill, the answer to this will fully depend on what people consider is to be 'ill'. Therefore, in case of Cuncani the author considers that the percentage of people suffering from waterborne diseases might be higher than the actual number obtained through the survey. Moreover, it is acknowledged the requirement of improving the methods used in terms of first determining people's perception of being 'healthy' and from that baseline it might be more accurate to obtain an estimate of incidence on waterborne diseases.

On the other hand, when it comes to the surveys, a variable that affected both depth and accuracy on the information gathered on each of the questions was related to the variables of gender and age from the interviewees. From personal observations, the author recognizes the fact that women and younger men were more willing to cooperate and to provide household information when interviewing them. The gender variable identified can confirm the statements previously emphasized by several authors in regard of the importance of women as changing agents of society and their sensitivity and participation when it comes to solving household issues related to health and their daily activities. In relation to the age variable identified, the author infers that improvements on education access have had a strong influence on the willingness from people to cooperate, to acknowledge the existence of water issues and health-related consequences and to make an effort on changing their current situation by participating in these types of researches.

7 Conclusions and Recommendations

This Chapter summarizes the main findings introduced and analysed in Chapters 5 and 6 in order to provide conclusions and further recommendations for relevant audience and for further research.

7.1 Main Findings and Conclusions

Aiming to improve the practical knowledge regarding sustainability on access to improved water services in rural communities from developing countries and furthermore, acknowledging the current situation from Peru in terms of achieving the MDG target towards improving sustainability and safe water access, the present thesis developed a case study in a Peruvian rural community with the intention to assess the current problematic and constraints on their water systems and to determine how a water purification technology could be successfully implemented and sustained in time.

On the other hand, the present thesis research has contributed to the existent body of literature by adding practical knowledge into the field of sustainable water services provision. Furthermore, by analyzing the current functioning of water services in a particular community and the complexity of actors involved together with the identification of main constraint factors, this research work was able to identify key elements using a more practical approach in order to improve the current understanding on water resources management from the National to the Local level. Additionally, as successful technological innovation relies on implementation and sustainability aspects, this thesis also contributed to grasp leading elements that are to be considered when working at the community level; this from the market deployment perspective as well as from the institutional arrangements perspective towards effective water services provision. In order to enhance understanding on the main findings of the present research, these will be presented by answering the research questions introduced in Chapter 1.

7.1.1 Safe and Sustainable Drinking Water Supply in Cuncani

With the aim of providing an answer to the research question No. 1 on why has Cuncani been unable to obtain and maintain in time a safe and sustainable drinking water supply, the following sub-questions were answered:

How does the current water system work in Cuncani?

Cuncani has had water access since the year 2010 and the community is able to obtain water through individual faucets that were installed in most households. Additionally, the Municipality of Urubamba was the responsible for installing this water system and by National directive from the Ministry of Health, the current water purification method used is based on chlorination. Moreover, based on a decentralization approach, the Municipality of Urubamba has delegated the responsibility of managing water systems to the JASS or water management boards from each community; this management involves operation and maintenance of the entire water system including the chlorination process. Furthermore, the Municipality is legally in charge of carrying on training programs to the JASS members and they ideally perform monitoring activities twice a year within the community. Finally, the Lares Health Center is legally in charge of monitoring water quality of Cuncani and additionally, they shall carry on education and training programs to all community members towards

raising awareness of water, sanitation, hygiene and health. No private business or NGOs are currently participating in the provision of water services in Cuncani.

In terms of cost sharing, according to Peruvian statutes communities are to pay a fee to the JASS so they can properly perform their work. However, this thesis found that almost no payments are currently being done due to the dissatisfaction from people with the JASS's performance. Furthermore, this research found that chlorination is not being properly performed by the JASS or the Municipality and as a consequence, 64.9% of the interviewed households reported suffering from stomach illnesses that might be attributed to poor water quality.

What are the main barriers constraining the safe drinking water access in Cuncani?

This research discovered that some of the strongest constraining elements are related to cultural barriers. Cuncani's cultural beliefs are against chlorine as a chemical that can jeopardize their health; therefore, no sense of ownership has been promoted, as people do not trust in water quality from their system. In addition to this, there is a fair low understanding on the relationship between water quality and health, which can be translated into the lack of demand for improved water services and lack of initiatives to seek for a replacement method for chlorination. Following cultural aspects, the tendency from Cuncani's members to normally expect for external support has constrained in them the sense of self-diligence. An additional element is related to the fairly weak and unstable education and training programs carried on by public authorities to raise awareness among people together with the low ability to retain the information obtained by community members. As a consequence of the low awareness, together with the fact the most people do not perceive an immediate tangible benefit from improved water services, willingness to pay is quite limited.

On the other hand, this thesis grasped as additional barrier the current ineffective institutional arrangements and the disaggregated stakeholders participation to manage water services; in this sense, there is a limited availability of resources and capabilities from local authorities to properly manage water services. Additionally, although not directly the case of water services, this lack of resources and capabilities has generally made local authorities to rely in NGOs to cope with responsibilities that are legally attributed to public authorities; this has promoted among community members a higher trust in NGOs than in public authorities. In terms of the water systems management, this thesis found that there is a fairly poor performance from the JASS when operating and maintaining water systems and also, there is a limited monitoring in terms of water quality and lack of enforcement from the Municipality when it comes to guaranteeing a proper water services provision. Finally, this thesis found that when it comes to the development of any project, almost no women participation is given within the community; this could be undermining Cuncani's possibility to strengthen participation and improving their decision-making processes by including women's perspectives on health and education, among others.

7.1.2 How can the D4field Technology be deployed in Cuncani?

With the aim of providing an answer to the research question No. 2 on how can the D4field technology be implemented and maintained in time in Cuncani, the following sub-questions were answered:

Which are the institutional and social structures that can support not only the implementation and long-term sustainability of the technology?

On the basis and boundary condition that Cuncani would need external support for affording the D4field or any other water-related technology, this thesis found that in the most convenient and fair participation scheme, the Municipality would play an important role by being responsible of both facilitating and affording the D4field. However, in order to enhance ownership and responsibility sense, the Community has also a key role by contributing with this investment but in a lower share, giving its lower availability of financial resources. Additionally, this research found that the Municipality is to be responsible for monitoring activities of water systems and of guaranteeing the proper water services provision. When it comes to the role of communities and the JASS, this thesis concludes that they have a critical role in the decision-making process for any project. The JASS board plays a fundamental function by working as leaders, innovators, communicators and has a strong responsibility within the operation and maintenance of the community's water systems; in case that these responsibilities are delegated to an external actor, the JASS would be critical for the internal monitoring of proper functioning of the community's water systems.

On the other hand, as the entrepreneur and provider of the D4field, Watersprint AB was defined as key actor for the training of the JASS given that water management boards are theoretically responsible for the operation and maintenance of the technology. However, in case the community agrees on having and affording external support, partnerships with local entrepreneurs and/or NGOs could promote a more effective services provision (in terms of operation and maintenance).

Additionally, according to National legislation the Health Center is responsible for the monitoring of water quality and educational programs towards enhancing knowledge on water, health, sanitation and hygiene. Finally, this thesis concludes that NGOs play an important role by working as supporters and facilitators on educational programs and water services provision by contributing with knowledge and their practical experience from their previous work with rural communities.

Which are the main drivers that can enhance both the implementation and long-term sustainability of the technology in Cuncani?

Among important drivers that this thesis found are the contextualization and understanding of the community's needs, cultural beliefs and preferences. In this sense, this research found that the first driver that could promote the implementation of the D4field is the actual interest and acceptation shown by Cuncani's members to this technology; due to its simple design and easy-to-explain functioning, a fair understanding was reached even in the poorest sectors. In addition to this, as suggested by different actors and reviewed authors, when it comes to sustainability of a services a strong focus should be placed on educating people to increase awareness on health and water quality, to instill a payment culture and finally to strengthen their sense of ownership in their water systems. On the same line, an important driver relates to increase awareness on the fundamental role of the JASS as community leaders, communicators and disseminators of technologies.

From the entrepreneurial perspective, this thesis grasped that a key element would be the provision and enforcement of a clear participatory framework in which Watersprint AB could participate in water services provision as well as the effective relationship that is to be established between Watersprint AB and the actors directly involved in these services in Cuncani; in this sense, it is fundamental to enhance communication, coordination and engagement among all relevant actors.

Finally, this thesis agrees with the idea that an efficient and effective combination of top-down and bottom-up approaches should be given for the sustainability of water services. In this

regard, considering the complexity of services provision, is suggested to have a convenient responsibilities distribution among the actors involved in this process.

What are the key parameters that the technology will improve in Cuncani's members and in public institutions and organizations?

The present research identified as main parameters that would be improved through the implementation of the D4field the following: health benefits through water quality improvements (health in terms of directly-related waterborne diseases and in malnutrition as well); reduction in health expenditure from both communities and public institutions such as health centers; enhancement of communities development and growth through the long-term benefits from health improvements; coordination and communication among different institutions can be improved through the practical knowledge of a pilot implementation project in a small community like Cuncani.

Finally, as the results of the present thesis proved a reduction in productive days (related to work and school activities), the author concludes that the D4field and its related health improvements will also increase the number and the quality of available productive days for community members. Thus, a cost-efficient and effective water purification solution has the potential to create a positive development spiral for the community. However, as emphasized in Chapter 6, this thesis reinforces the importance of water quality together with proper hygiene practices in households in order to reach the highest level of health benefits, productivity, community development and growth.

7.2 Reflections of the Research

After the rich learning process from this thesis, different reflections can be given. First of all, in terms of the limitations established at the beginning of this research process, in reality these did not play a significant role on the achievement of the aims of this thesis. Participation from the different actors including community members was particularly high and because of that, this thesis was able to gather all required data to reach a quite favorable understanding level and to provide answers for the established research questions. Additionally, the limitation of having a translator from Quechua dialect to Spanish resulted in a higher response rate from community members when doing the survey; in this way, as a trusted community member was selected to participate as the official translator, this promoted a higher participation and trust among people when introducing the author to every household. Therefore, it is suggested promoting agreements with community leaders when carrying out these types of research in order to boost people's participation.

Furthermore, by learning from the dynamics among different actors, this thesis was able to evidence how even a case study on such a small community can involve a significantly high complexity around water governance and the sustainability of water services. Even though every community has particularities in terms of social, cultural, economic and political elements, most of rural communities are facing similar challenges to sustain themselves and to develop. Therefore, the key learning lessons that were grasped and previously mentioned can be of great contribution for different societal levels. Similarly, although this research was carried out using the D4field as the technology to be hypothetically implemented, the contributions and learning experiences from this thesis could be generalizable to other water purification technologies that could be culturally accepted by communities such as Cuncani.

Regarding the water governance frameworks reviewed in this research, although useful to set a baseline for the analysis of the thesis findings, after the practical learning experience from the present work, some improvement opportunities were identified. For instance, even though the

frameworks place a strong focus on communities and its participation in services provision, the fundamental aspect of instilling a payment culture among them would also play a key role in the sustainability of any service. Similarly, as proved by this thesis, the lack of effective monitoring systems can hinder the sustainability of a service. Finally, the role of entrepreneurs and their importance in the creation of public-private partnerships for effective services provision seems to be unclear or even absent in some of the frameworks that were reviewed. Therefore, aiming to contribute in theoretical aspects of water governance, this thesis suggests placing a stronger focus on these principles within any framework to be developed and applied in the future.

7.3 Observations and Recommendations to the Relevant Audience

Watersprint AB: based on personal observations from the author, as communities normally have a much higher trust level in NGOs in comparison with any other local authority, the author suggests that a convenient strategic approach to start deploying markets for the D4field would be to create partnerships with NGOs; not only people trust in these organizations but NGOs also have a fairly high knowledge on communities characteristics that can be quite useful for Watersprint AB. Besides this, given all bureaucratic procedures to work with Municipalities, would be much more effective and straightforward to create partnerships with NGOs as a starting point.

Additionally, given that these types of communities are fairly vulnerable and with low financial capabilities, the author emphasizes to Watersprint AB to not expect a pure market-based business model, mainly because communities need external support to be able to afford its products. A suggestion in this case would be to make technologies more affordable in order to reach a point in which communities will not have the need to rely on external support to afford clean water. Among ways to do this would be to find external donors to finance the production of the D4field and also to develop a business model in which the Company has different products targeted for different types of consumers depending on their financial capabilities; in this way profit from other products might be used to offset the affordable price of the D4field.

Public Authorities: the author reinforces their fundamental role on promoting hygiene practices and sanitation together with water quality improvements. Furthermore, it is suggested that public authorities might consider these improvements as opportunities to make their communities much more productive in every sense and consequently, lowering the required work and future investments from public institutions on rural communities. Additionally, given the touristic potential of communities such as Cuncani; any improvement could also be considered as an opportunity to increase their attractiveness for tourist activities, thus promoting further community development and growth.

Additionally, from conversations with representatives from public authorities, the author perceived a quite strong sense of having chlorination as water purification method regardless the context in which is implemented. In this sense, it is suggested that changing mindsets will not only apply for community members, but also for public authorities in terms of improving their knowledge in water treatment methods and investigating the possible alternatives that could be more suitable for rural communities. Public authorities have a quite strong reason to improve their current water purification systems; not only they are not culturally accepted by some communities but also have not delivered the required results in terms of health benefits, and as proved in this thesis, community members are suffering from illnesses that might be related to poor water quality.

Non-governmental Organizations: the author suggests that a clear understanding on their role as supporters in fundamental. Given their wide knowledge in many aspects of communities, the trust that communities place on them and their relationship with local authorities, NGOs have a strong potential to increase effectiveness of public institutions when it comes to the promotion of hygiene practices and towards the improvement of general knowledge (technical, social, political, among others) from communities and from public authorities.

On the other hand, NGOs play a fundamental role when it comes to supporting public-private partnerships; their work as facilitators between public actors, communities and entrepreneurs could definitely boost the development of many different projects. In this sense, the author suggests that NGOs could also explore their possible role as drivers for the implementation of water-related technologies; by having the initiative to improve water quality, they could as well explore and look for water solutions to then facilitate as mediators its implementation and long-term sustainability.

International Research Communities: if a holistic approach is to be the baseline to develop water governance frameworks, the author suggests to focus future research on defining and clarifying how the most effective participation approach could work in terms of involving the private sector and local entrepreneurs within water services provision. Entrepreneurs' participation is considered when relating to sustainability of water services within operation and maintenance tasks; however, their crucial role is not clearly defined from the policy-design phase.

On the other hand, it would also be quite interesting to develop research focusing on the practical elements that would enhance and/or constrain a situation in which communities and entrepreneurs work together without relying so much on external support from public authorities and/organizations. Additionally, the author perceived a tendency to divide the water-policy design phase from the practical elements supporting sustainability within a particular community; in this sense, a holistic approach could involve a study from every stage in the project cycle from the policy design phase to the actual application in a particular context.

7.4 Suggestions for Future Research

After the learning process for the development of this thesis, the author makes some suggestions for further research. As the study of a service provision and the actors involved is quite complex, in order to provide a deeper understanding and to increase the variety of suggested ideas, the author recommends to develop different focus groups activities but within each of the institutions. Although the dynamics and interactions among the different actors was quite interesting, it might be convenient to first develop the same activity only with personnel from each institution. In this way, much relevant data could be gathered to then prepare an interactive focus group with all relevant actors.

Additionally, if possible, it is suggested to gather data in relation to specific expenditures from the Municipality and Health Centers to develop indicators on the overall possible economic benefits from the implementation of a technology such as the D4field. Furthermore, the author also suggests performing water tests in every specific community in order to verify the degree of relevance between water quality and hygiene.

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Appendix I: Interviews

Chamberlain, Kate: Co-founder of HARBEC Plastics in the United States of America (Interview via Skype).

Hart, Sany: Founder of the NGO Desea Peru in Lamay town.

Kozuch, Alicia: Co-founder of Buen Power Company in Cuzco City – Peru.

Rodriguez, Elizabeth: Head of the Water and Sanitation Office from the Municipality of Urubamba.

Vasquez, Marybell: Doctor at the Lares Health Center, closest physician to Cuncani's medical patients.

Focus Group Participants

Paz, Arturo: Member of the NGO Pro-Peru in Urubamba.

Quispe, Prisila: Nurse from the Urubamba's Health Center and the *Dirección Regional de Salud* (DIRESA).

Rodriguez, Elizabeth: Head of the Water and Sanitation Office from the Municipality of Urubamba.

Sallo, Saturnina: Community member from Cuncani and active leader on discussions within the community.

Stieglitz, Adam: Member of the NGO Alianza Andina in Urubamba.

Tarassenko, Jean Gabriel: Member of the NGO Nexos Comunitarios in Urubamba.

Vasquez, Marybell: Doctor at the Lares Health Center, closest physician to Cuncani's medical patients.

Appendix II: Questions for Interviews

Interview with Elizabeth Rodríguez (Municipality of Urubamba)

1) Is the quality from Cuncani's drinking water evaluated? Who is in charge of doing this and how often is it done?

2) Have you detected any issues with Cuncani's water quality? If so, how recent? Is it currently solved?

3) What type of treatment is being applied to Cuncani's water in order to guarantee that is safe for human consumption?

4) Do you have any support from the National and/or Regional government? If so, what type of support? (for example: financial, capacitation programs for your workers, etc)

5) Is the Water and Sanitation office well institutionalized? In terms of having qualified and trained personnel and the required budget to implement your water and sanitation programs

6) What is your relationship with the JASS of Cuncani (water and sanitation management boards within each community)? And what type of support do you provide for them? What is established (according to regional and municipal legislation) to be their role within water services management?

7) If there is to be a technology that can potentially fit into a particular community and can solve water quality issues, does the municipality have any participation on the implementation and maintenance of it? For example, would you be capable and willing of providing support to a community such as Cuncani? Considering their low financial resources and poor life conditions they currently have.

8) Are there any possible partnerships between the municipality, private companies and NGOs in order to achieve the successful implementation of water-related technologies?

Interview with Marybell Vasquez (Lares Health Center)

1) What types of diseases are more common from people in Cuncani?

2) What are the most common stomach diseases in Cuncani and from which people come to this health center? Have you been able to successfully treat them? (in terms of having all medical medical supplies to treat them) Who are the most vulnerable to these diseases? (for example elderly, kids between certain ages, etc)

3) Do you have any relationships with the Ministry of Health and with regional authorities such as DIRESA?

4) Have this health center participated in any capacitation plan or health campaigns to prevent diseases coming from poor water quality? (for example to teach community members how can they prevent getting sick)

5) How important for people's health do you think is to drink clean water? What preventative measures do you recommend to avoid getting ill?

6) Do you think that patients do take in consideration all your medical recommendations regarding hygiene and water sanitation?

7) Do you think that patients know the fact that parasites, bacteriological diseases such as diarrhea come from consuming unsafe water?

Interview with Sandy Hart (NGO Desea Peru)

1) What made you start with the implementation of water filters in this community?

2) Was the water from this community already being treated with for example Chlorine? Before you implemented these filters.

3) How is your system sustained? Do you charge a purchase and/or maintenance fee?

4) What type of relationship do you have with local authorities? Do you receive any support from them?

5) Do you think that the JASS (local management boards for water and sanitation services) are effective when dealing and managing water systems? Do they receive training from authorities?

6) What are the key elements that have contributed to make your system sustainable?

7) What were the main barriers you found when first implementing and then maintaining your project?

8) Do you have any comments or recommendations for my thesis?

Interview with Kate Chamberlain (HARBEC Plastics)

1) What made you start with the implementation of the Better Water Maker in Cuncani? What type of previous studies did you carry on before implementing this great technology? For example, did you make water analysis, surveys to community members and health centers, etc.

2) Was the water from Cuncani community already being treated when you implemented the BWM? with for example Chlorine.

3) As far as I know, the BWM for some unfortunate reason stopped working and the people from the community have not been able to fix it because they lack of technical knowledge to do this. Considering this fact, how do you make your projects sustainable in time? Do you plan to provide for community training for them to be in charge of their systems or do you plan to work directly with the community in order to provide them support?

4) On the same line, what are the key elements you think will contribute to make your systems with the BWM sustainable and also affordable to people? As an organization, are you financially capable to always donate devices like the BWM or do you suggest that in the future these devices should be charged in some affordable way?

5) What were the main barriers you found when implementing your technology?

6) During the implementation phase and in your project itself, did you have any relationship with the local government from Urubamba? Did you receive any support from them? if so, what type of support? for example, providing training programs for community members, financial support to afford the BWM, etc.

7) As for Peruvian legislation, water and sanitation systems are locally managed and operated by the so-called JASS (in english would be the management boards for water and sanitation services). Do you have any knowledge or experiences on how effective this JASS is in Cuncani? Do you know if they have received any training or capacitation to perform their work?

8) Can I ask what is the regular cost for a device like the BWM? When they are not donated, how much do they cost?

Interview with Alicia Kozuch (Buen Power Peru)

1) What were the elements that made you start with the implementation (sales) of solar products in rural communities?

2) Did you carry on any previous studies before implementing your products? Feasibility studies for example.

3) How do you manage to make your business sustainable in time? Not just in terms of the acquisition of your products from rural communities but also the maintenance in time.

4) Who is in charge of the maintenance of your products? If it is your Company, do you charge a maintenance fee for this service?

5) What type of relationship do you have with local and/or regional governments? Do you obtain any support from them?

6) What are the key elements you believe have made your business successful? Especially when working with rural communities

7) Which have been the main barriers you have faced when entering the rural communities market?

8) Previous research indicates a low private business's participation to provide services in rural communities given the low-profit margins that this participation represents. Is this the case for Buen Power? If so, how have you managed to make your business economically sustainable?

9) Will you be willing to expand your business not only focusing on electricity but into other services? Like for example into water services? (Here I explained the idea of implementing the D4field and the idea of having them participating in the distribution of this product)

Appendix III: Interview Example

Interview with Alicia Kozuch, Co-Founder of "Buen Power" Company – Cusco (Peru). March 16th, 2015

1) **What were the elements that made you start with the implementation (sales) of solar products in rural communities?**

The interviewee mentioned that she worked in the previous years as a volunteer in different communities from "Ollantaytambo" and so she started to perceive the energy needs from this people. After this, she and her brother (both engineers) installed 2 solar panels in a rural community to study people's reaction. Surprisingly, people asked them how they could also bring this system into their households.

2) **Did you carry on any previous studies before implementing your products? Feasibility studies for example.**

She indicated that there was no formal study with surveys or anything. However, after building the solar panels, they distributed some sample products among different families and gave them a one-month testing period. After this period of time, she went back and found people fascinated with their products and asking for more. Therefore, from this and her previous experiences with rural communities she decided to formally start with "Buen Power" Company.

3) **How do you manage to make your business sustainable in time? Not just in terms of the acquisition of your products from rural communities but also the maintenance in time.**

First of all, the Company has products which are affordable to people and not only that, but the interviewee highlighted that as the communities actually demanded for this service, they perceive the value of having this service; therefore, the community has a strong interest in maintaining the products they bought.

Also, the Company works with small entrepreneurs that are mostly teachers who work in every school from different communities. They come to us and buy our products and then re-sell them directly to the communities (sometimes at the same price but mostly at higher prices). These small entrepreneurs facilitate our work and specially help us with the geographical limitation and barrier that we have to overcome in order to reach every community.

Additionally, we also work with NGOs and different organizations (USAID, NESST, among others) who help to subsidize our products and in the cases they see more need and less resources (particularly in communities living in extreme poverty), then they provide these products to people sometimes for free or by subsidizing a high part of the total cost. Additionally, the NGOs also support us to spread the word about our products among communities and facilitate our work by being intermediaries between the communities and us. Again, as they work with very specific communities, they help us to overcome the geographical barrier to access them.

4) **Who is in charge of the maintenance of your products? If it is your Company, do you charge a maintenance fee for this service?**

How it works is that when we sell our products we explain in detail how they have to use it in order to maintain the integrity of the product and make it last its entire lifetime. For example, we have a 2-year warranty and our products should last around 5 years. Therefore, if people follow our instructions, our products should be able to work without any maintenance. However, we have had cases in which people have had certain issues with some products; in these cases, if the issues are covered by the warranty (manufacture defects for example) then we fix them without charging any fee. Additionally, if the issues are outside the warranty range and the product gets broken due to the customer's misuse, then we charge a fee to repair the devices.

5) **What type of relationship do you have with local and/or regional governments? Do you obtain any support from them?**

We try to work with local authorities and implement our products through projects developed by them. However, this work is quite difficult; there is a lot of corruption in these institutions and sometimes lack of political willingness to do the right things. Also, you need to have contacts and move through them if projects are to get started.

6) **What are the key elements you believe have made your business successful? Especially when working with rural communities**

First of all, we managed to establish a reputation of good quality of the services provided by our products and through this reputation we also obtained trust from community members. Second, I think that a key element for our success was the fact that we are two Co-Founders, me (from the USA) and a Peruvian who was born in the Cusco Region, speaks Quechua and knows the reality of the communities. Therefore, with the combination of both co-founder's attributes (my business vision and his ability to dialogue with community members and organizations) we have managed to reach our current success level.

7) **Which have been the main barriers you have faced when entering the rural communities market?**

I think that the main barrier in these types of communities is the lack of education. People are terribly used to receive things for free and not necessarily to work for them; this is matter of lack of education and lack of a long-term vision. This terrible culture has been spread due to different reasons; I think the first one is that governments are not willing to build capacities among different communities; they prefer to keep people with a level of knowledge in which they can have a certain "control" over them. Second, I think that NGOs are kind of "guilty" for this culture, because they also provided people with lots of free things and now every time communities see foreigners or people from NGOs, they just think that they will get more free things and the solution to their problems.

The other barrier that was previously mentioned was the geographical barrier. There are many communities high in the mountains and most of the time the only way to access them is by hiking; so it is pretty difficult to do this within our job, also because we do not have that many people working for us.

8) **Previous research indicates a low private business's participation to provide services in rural communities given the low-profit margins that this participation represents. Is this the case for Buen Power? If so, how have you managed to make your business economically sustainable?**

Yes, but we have managed to make our products affordable to people while at the same time covering our profit margins. Our strategies in this case are basically two; first, as previously mentioned we work with external donors and organizations who subsidize our products to certain communities. The second one is by diversifying our product catalogue; in this sense, we have developed bigger-scale products targeted for people living in the cities (who have a higher purchasing ability) and with the profit margins from these products, we have managed to keep our affordable prices within the products which are targeted for rural communities.

9) **Will you be willing to expand your business not only focusing on electricity but into other services? Like for example into water services? (Here I explained the idea of implementing the D4field and the idea of having them participating in the distribution of this product)**

In the case of the water field, I think that there are many barriers to entry that have to be overcome in order for us to start having a view also into this market. For example, people are quite willing to pay for our electricity-related products because they see an immediate benefit from them; first, they have light in their households and second, they immediately perceive a lower expenditure on electricity (which in their case it used to represent around 20% of their income, which they spent in fuels, wood, etc). With water the case is different. I know all the benefits from drinking clean water; however, I think that these benefits are not immediately tangible by people. They do get sick, but I believe they only spend in health in case they get seriously sick. Therefore, in my opinion they will not have an immediate economic or health benefit from having clean water. Besides this, our perception of being "healthy" is quite different from theirs; for example, they usually take for granted the fact that as they live in the mountains under certain conditions, then they "should" be sick and they just have to get used to this fact. Hence, there is a strong cultural barrier that needs to be overcome in this sense.

All of this has obviously to do with the weak education they have when talking about health. Therefore, if the implementation of a purifying water technology is to be achieved, first you need to put a strong effort on educating people. Remember that they need to be the ones demanding for a service if you want them to maintain it; they need to perceive the actual need of a particular service before starting with any implementation project.

Appendix IV: Survey in Cuncani (Questions)

Name__ Number of inhabitants__ Number of children__

Section A: General issues and health

1) From where do you get the water that you use to drink and cook at home?
2) Which are the most common diseases that you deal with at home? Who suffers the most these diseases?
3) How often do you get sick from the stomach?
4) Do you usually stop your daily activities (work in your land, going to school, among others) because of stomach diseases?
5) Why do you think you can get sick from your stomach?

Note 1: if they do not say anything related to water, questions 5.a and 5.b will apply

Note 2: if they answer something related to water quality, question 6 applies

5.a) Do you believe that the water you drink have any problems? Like contamination problems

5.b) How do you believe these problems can affect your health?

6) Approximately how much money do you spend every time you get sick from your stomach? (Between medicines, transportation, etc)
7) Do you often drink water during the day? How much water approximately do you drink per day? Do you often use water to cook?
8) Do you think that water is important for your health and daily activities?

. **Section B: Technology-related issues**

1) Do you know the water purifier device that was installed in the school (the Better Water Maker? What do you think about it?
2) Why do you think it is currently not working?
3) Would you like to have this device operating again?
4) Approximately how much money do you spend in drinking water at home? (Monthly, weekly, etc)
5) Do you believe it is necessary to purify water from your home and community? Which do you think is the best way to do this?
6) What do you think of this technology? (D4field) Would you be willing to have it at home?

Section C: JASS and water management elements

1) Do you know the JASS from Cuncani? What do you think of their work?

2) Would you like to improve something from them? What?
3) Do you do any payments to the JASS to be able to have water access at home? How much?
4) Do you think that water services should be paid in your community?
5) Would you be willing to participate in any training programs to manage better your water and health?

Appendix V: Questions for Focus Group Activity

Warm-up questions:

1) Which are the elements you think have constrained Cuncani from having safe and constant water services for human consumption?
2) Do you think that chlorination, as a water treatment method, is effective and accepted by Cuncani members?
3) Do you believe that there is a need of diversifying the methods used to treat water in Cuncani?

Deep-in-the-field questions:

4) Which are the elements you think shall be considered when implementing and maintaining in time a technology in a rural community like Cuncani? (This technology does not necessarily has to be a water technology, this because not all the NGOs have experience with these particular types of technologies but they still can have important insights)
5) Who do you think shall be involved and participate in the different phases of implementing and monitoring a technology in a rural community like Cuncani?
6) What do you think the role of the JASS (water management boards from the community) should be when implementing and maintaining this technology?
7) Who should pay for this technology? (Both for the purchase itself and then for the monitoring)