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Providing Clean Water to Rural Communities

Cases from Mexico

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"This thesis is dedicated to the millions of people struggling to access clean water"

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Abstract

Despite the international efforts, clean water provision to all remains a task to be solved around the world. As this challenge accentuates in rural areas, this thesis contributes to the body of knowledge of clean water provision in to rural communities, focusing on seven cases from Guanajuato and Oaxaca in Mexico. The complex system set in place to guarantee the human right to access, safe, sufficient and acceptable water to everyone in Mexico is critically analyzed throughout the thesis. This research work uncovers many of the challenges deterring clean water provision in rural areas, including water scarcity, water contamination, poverty conditions, social conflict, weak capacities and lack of planning from local governments along with their unwillingness to act and at the same time looks at constructive practices. This thesis explores the existing literature on the subject, in order to outline and weight optimal conditions for ensuring sustained clean water provision systems, emphasizing in, community engagement, ideal government's involvement, accurate assessment of local context and appropriate technical solutions. A qualitative examination takes place in selected case studies aiming to analyze the aforementioned conditions. For designing a practical solution, this research project included the arrangement for the donation of a water purification device (PAUL), in order to develop and assess the implementation of a technical solution (water purification) in to a rural community based on the lessons obtained during the research course.

Keywords: Clean Water Provision Systems, Rural Communities, Mexico, Guanajuato, Practical Example, PAUL

Executive Summary

Considering the importance of water for human existence, the United Nations include clean water provision for all as one of the main challenges to be solved around the world. For that reason, this thesis investigated the provision of clean water in to rural communities, taking a practical approach to deliver policy recommendations focusing in seven cases from Mexico.

Current estimations suggest that globally about 663 million people lack access to clean water and improved sanitation conditions, about 2 million deaths occur each related to inadequate poor water supply and hygiene.

In Mexico, there has been a good progress in recent decades in terms of increasing the rate of water provision, however, today not everyone can fully enjoy the right to access safe, sufficient, acceptable and affordable water as it is mandated by the Mexican Constitution. For that reason, a complex system involving different levels of government and responsibilities is set in place to insure water provision, the Mexican system decrees that Municipalities are the main responsible for ensuring water provision.

Many challenges deterred clean water provision in to all rural communities; these vary depending on local context but mainly lie in the lack of financial and technical capacities from municipalities, poverty conditions in rural areas, water scarcity, and contamination of water sources, social conflict and mismanagement of resources.

In order to investigate the context of water provision, this research followed various methods including interviews to relevant stakeholders, experts and practitioners on the field, as well the gathering of qualitative and quantitative data in the selected cases studies.

The findings of this thesis suggest that clean water provision goes beyond the installation of technical capacities, as it can be a complex process in terms of its prioritization on public agendas, number of actors, bureaucratic procedures, and local challenges.

Official estimations suggest that currently in Mexico about 18% of total households in rural areas lack access to piped water and those with access to it doesn't necessarily mean that it is clean.

After revising the literature on the subject, a series of conditions for sustaining clean water provision systems were selected for the analysis of case studies. These conditions include firstly, *Community Engagement,* as it means that enough members from the community are engaged in the Clean Water Provision System (CWPS) and that mechanisms are in place that enable an equal participation and contribution of all actors.

Government's Involvement is crucial for ensuring clean water provision, mainly in controlling and monitoring the CWPS. Local governments must get involved in order to enhance financial and technical capacities, and reduce the water affordability burden when needed. *Sustainability in Decision-Making and Planning* is recommended in order to ensure enduring systems. *Consolidation of Responsible Local Actors* enhances the strength of local institutions and resilience of the CWPS.

An *Accurate Assessment* of Social, Economic and Environmental aspects as well as technical conditions is important as rural communities can have similar settings but each has unique characteristics, policy implementation should always look at each context and address its needs accordingly.

Mechanisms for *Self-Financing* are important to ensure continuous operation and increase resilience of CWPS. An important aspect to consider is that water should not be considered as a commercial good, in order to guarantee the human right of access to water. At the same time,

all stakeholders should fairly contribute to the system by paying their water fees, and contributing to the good management and use of systems. Subsidies from governments should be considered when needed.

A *Regulatory Framework* is needed ensuring the operation of CWPS, conflict resolution and allocation of responsibilities. Appropriate *Technical Conditions* can ensure sufficient and clean water provision and (most) users accept and use them.

Training and Education to locals is an important task during project implementations. The content covered should include the management, operation, and maintenance of CWPS, and the importance of hygiene practices and payment culture. An *Effective Control and Follow-up* by responsible agencies or stakeholders is an important aspect to ensure good conditions and long-term operation.

The framework of conditions proved to be a helpful framework for the analysis of case studies. A discussion on the relevance of these conditions demonstrated that each has different levels of importance, and that this tool can be use in similar cases if adapted suitably.

Regarding the findings from relevant stakeholders, they confirmed the current relevance of the topic, they suggest that concrete goals, cooperation and demand-based approaches help as good drivers to increase water provision. Experts recommended pilot projects in order to tests solutions before technical implementations of water solutions and an accompaniment and follow-up as a crucial phase in the development of any CWPS. Considering the needs of many rural communities, water purification solutions should be: durable, cost-effective, low maintenance and preferably low-energy intensive or power-free.

Studied communities proved to have different settings in place for obtaining water. In some of them clean water provision is inexistent. Conflict among members, lack of government's involvement, poverty conditions, and lack of financial and technical capacities proved to be the main defies against CWPS. While in others, such as in the case of San Antonio del Barrio, appraising levels of cooperation, direct democracy and collective action greatly supported CWPS.

This thesis made used of photography, enabling the author to capture essential moments from this experience. Photos portrayed along the thesis enable the reader to envisage case studies.

PAUL – Portable Aqua Unit for Lifesaving is an innovative water purification device designed at Kassel University in Germany for after disaster situations, enabling to provide clean water for up to 400 people, however, permanent installations have proven to be successful.

This research project included the arrangement for the donation of a water purification device (PAUL) in order to test and develop a practical example, and recommend guidelines to effectively deploy a technical solution in to a rural community.

In summary this thesis analyzes the water provision system in Mexico focusing in rural communities, outlines a series of conditions for sustaining CWPS, and develops a practical example for a successful implementation derived from the lessons and content gathered during the thesis.

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Abbreviations

BANOBRAS	Mexican Bank for Infrastructure Development
BID	Inter-American Development Bank
CDI	National Commission for the Development of Indigenous People
CEAG	State Water Commission of Guanajuato
CIATEC	Research Center for Innovation and Technology
CONAGUA	Mexican Water Commission
CONAVI	Mexican Commission for Housing
CWPS	Clean Water Provision System
INEGI	Mexican Institute for National Statistics and Geography
MESPOM	Masters in Environmental Sciences, Policy and Management
NGO	Non-Governmental Organization
PROSSAPYS	Federal Program for Water Infrastructure and Sanitation in Rural Areas
OECD	Organization for Economic Co-operation and Development
PAUL	Portable Aqua Unit for Lifesaving
SAB	San Antonio del Barrio
SEDESOL	Mexican Secretariat for Social Development
SEMARNAT	Mexican Secretariat for the Environment and Natural Resources
SIMAPAG	Municipal Water Agency of Guanajuato
UN	United Nations
UN-WATER	UN inter-agency for all freshwater related issues
UNDP	United Nations Development Program
UNICEF	United Nation's Children Fund
WHO	World Health Organization

1 Introduction

"Access to clean water is a right not a privilege, everyone should have access to it, yet at the same time contribute for it"

Water is essential for human existence, without any doubts water is the most important resource for any society, as it serves many purposes: for drinking, for growing food and its preparation, hygiene, for keeping vegetation and animals, and for a variety of other social and cultural uses. Even though our blue planet is mostly cover with it, estimations suggest that only about 2.5% of total water is fresh, and out of it, only a slight percentage (0.6%) is reachable for human consumption.

The World Health Organization (WHO) states that a person needs at least 50 liters per day to ensure his basic needs. Today, clean water provision to all, still presents a challenge to be solved. Inaccessibility to clean water is related to poverty, one of the major obstacles today to meet sustainable development for all.

Current population growth stresses water availability and increases the challenge for its provision and treatment. That is why problems related to water are expected to increase worldwide in the coming decades, mainly related to water scarcity and contamination. For this reason multidisciplinary approaches and innovative ways of purifying water along with successful implementations of water solutions are still to be developed in order to address this present challenge (Shannon et al., 2008).

Poverty, lack of knowledge and technical capacities signify the biggest challenges for clean water access in rural communities. The complex dispersion and limited access to many rural communities presents a stern defy for local authorities to insure water provision for all (Carrasco Mantilla, 2011).

As there are countless papers relating to the provision of such basic resource, this thesis aims to contribute to the body of knowledge relating clean water provision in to rural communities, taking a practical approach focusing on different case studies from Mexico.

1.1 Problem Definition

This section covers the relevance of this research course, being clear the importance of water for human life.

1.1.1 Clean Water Supply: A Global Challenge

Estimations done by the Joint Monitoring Programme for Water Supply and Sanitation from the World Health Organization (WHO), and the United Nations Children's Emergency Fund (UNICEF) suggest that, in 2015 about 663 million people lacked access to safe drinking water sources, and where water is provided is not necessarily safe (UNICEF, 2016). In other words, that figure means that still to this day: roughly, one out of ten people living on the Planet suffer the consequences of not having access to clean water.

A diminish quality and quantity of water, can lead to social conflict, disputes, and ultimately affect well-being (Wiek & Larson, 2012).

The World Health Organization (2003) states that the lack of access to clean water limits community development, in the opposite, making more water available can improve families´ quality of live. An additional aspect is that the lack of water, and appropriate sanitation facilities

in schools, can have a great impact on school attendance and increase drop-out rates diminishing education (Knight, 2003).

Poor water conditions can lead to life impoverishment by increasing water borne diseases. The WHO estimates that yearly about 2 million people die as a result of unsafe water, poor sanitation and hygiene conditions (WHO, 2016). Another relevant problem is that in some places water is polluted with unsafe levels of toxic elements such as, mercury, arsenic and fluorides that have been proven to lead to diverse health conditions. For instance, the WHO (2007) states that toxic contaminants in water, can cause dental and bone problems, kidney diseases, cancer, or affect brain development (Wang et al., 2007).

It was in the year 2000, when the Millennium Development Goals (MDGs) were adopted by 189 nations. One of these goals, targeted to halve by 2015 the proportion of all people lacking access to safe drinking water and basic sanitation, and at the same time to enhance the efforts of monitoring and assessing water quality, especially in developing nations (UN, 2015).

By 2010, the UN declared access to clean water and sanitation a human right. This precept, compels nations to work in order to ensure this right. According to UN-Water, in order to get full access to this right, any water provision system should guarantee the following features:

- **Accessibility** (this term comprehends a series of rights and freedoms: ensure the right of access against illegal and arbitrary disconnections, non-discrimination in access to clean water, not threatened when accessing water or sanitation outside home, water source should be at least within a 1000 meters from home and water collection time should not exceed 30 minutes)
- **Affordability** (water cost should not exceed 3 per cent of household income)
- **Adequate quality** (for human use)
- **Sufficiency** (sufficient amount of clean water for personal and domestic uses only)
- **Continuity** (continuous supply of water) (UN-Water, 2015).

For decades, there have been numerous efforts to ensure water access, however, the work is not done yet and continues today. After the time frame of the MDGs, in September 2015, nations around the World adopted the "2030 Agenda for Sustainable Development", with this in mind, 17 goals were adopted to promote prosperity for all, and to put an end to poverty. Goal number 6 is dedicated to sustainable management and availability of water and sanitation for all. At the same time, UN-Water suggests to develop governance frameworks for the provision of clean water (UN, 2016).

The Sustainable Development Goals are 17 goals adopted in 2015 by the United Nations to tackle a series of issues with the commitment of eradicating poverty.

An important note is that throughout this thesis, clean water refers to that water that has the quality of being safe, pure in order for it to be drinkable, and that normally has gone to an appropriate purification process, and qualified operators constantly control the network provision.

1.1.2 An Issue of Governance

Even though research and development has allow for innovative methods of purifying water, several experts and international organizations (UN-Water, 2006), coincide that the lack of

governance frameworks based on local contexts, inequity and mismanagement have led to the public problem related to water provision.

Franks and Cleaver (2007) suggest that governance is a good framework to conceptualize how distinct actors in society act together to manage its own affairs. Sadly, there is not one ideal framework to implement water provision in to rural communities. After doing a revision on existing literature, Peltz suggests, that many projects for water provision failed mainly because to the lack of comprehending of context, ineffective support structures and public participation (Peltz, 2007).

Carrasco-Mantilla argues that, many rural communities lack access to water due to higher costs of infrastructure development and less of a political impact (less voters) compared to urban settings (Carrasco Mantilla, 2011).

Even though a number of research has been done in designing new methods for the purification of water and its safe storage, only a few have been done on drinking water governance, especially in frameworks for rural communities (Kayser, Amjad, Dalcanale, Bartram, & Bentley, 2015). For this reason, Kayser et al. (2015) developed a term that they called "Drinking Water Quality Governance", that looks to improve the provision of water and address public health concerns related to water borne diseases.

In many cases, technological breakthroughs have allowed for new and innovative solutions to help tackle the trouble of clean water provision, however, it seems clear that technology alone, will not solve the problem but an approach that takes in to account economic, social and environmental aspects that promote a sustainable development (Hassing, 2009)

Nowadays efforts should focus to increase the provision rate of clean water as according to UN-Water (2013), as one of the main problem lies not only in the provision but also in the quality of water provided.

As this research study focuses in the case of Mexico, the next section covers the aspects of clean water provision in Mexico.

1.1.3 Clean Water Provision in Mexico: A Challenge to be Solved

In Mexico, several federal agencies link access to public services and poverty alleviation. If any community lacks basic services such as clean water, primary education, health, and electricity, it is considered to be in poverty conditions (D. F. Barnes, 2007).

> In 2010, water borne diseases were the third leading cause of deaths in children under one-year-old in Mexico (INEGI, 2016).

A recent report from UN-Water (2013) signaled that about 1.7% of total deaths in Mexico were due to water, sanitation and hygiene issues

At the same time, UN-Water indicated in 2013 that Mexico faces a series of problems related to water including: the increasing water scarcity driven by deforestation and population growth, an increased demand of water by the industrial and agriculture sector, water contamination and the expected negative impacts of anthropogenic climate change (UN-Water, 2013).

INEGI (2016) estimates that in Mexico, 77% of total water usage is used for agriculture; 14% for public water supply; 5% for thermoelectric power and 4% for the industry. INEGI is the acronym for the Mexican Institute for National Statistics and Geography.

Research on water provision in Mexico seems important as between 2003 to 2011, Mexico spent on average 1.8% of its total budget in expenses related to the water sector, representing on average 1,952.51 (million constant 2010 USD) yearly (UN-Water, 2013).

There has been a good progress in terms of increasing water provision in Mexico, in 1990, 77.1% of total households had access to piped water, by 2014, estimations suggest that THIS figure increased to about 92.3% (INEGI 2014). Being the penetration rate in urban areas of about 95.4%, and in the rural ones of 82% as shown on Figure 1-1 (CONAGUA, 2014).

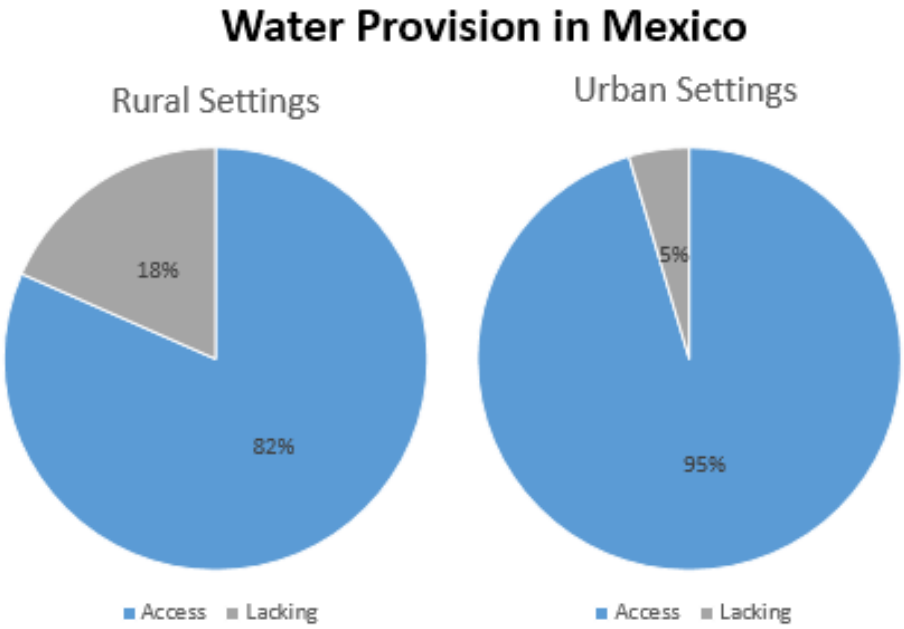


Figure 1-1 Rate of water provision in mexican households in 2014

Source: (CONAGUA, 2014)

The rest, those without access to piped water, get it from springs, wells, dams, rivers, streams, or other nearby houses, many times with insufficient drinking quality (INEGI, 2016). Considering so, many people lacking access to clean water in Mexico live in decentralized rural settings, making it difficult to reach to them.

Although rural population has been decreasing over time, it is important to mention that in 2010 about 23.2% of Mexican population lived in rural communities (INEGI, 2016).

In the case of the States of Guanajuato and Oaxaca, where this research was focused, respectively 30.1% and 52.6% of total population lived in rural communities in 2010 (INEGI, 2010).

This thesis uses the official definition of rural communities in Mexico presented by INEGI (2016), hence, those communities with less than 2500 inhabitants.

In Mexico many people living in rural communities are getting water through improvised systems; many times this water does not receive any treatment or it is insufficient for its human consumption (INEGI, 2010). In consequence, in many cases the main issue is not about piped

water provision, but rather the quality of the water for its domestic consumption including for drinking purposes.

1.1.4 Suitability and Pragmatism of Water Research

Countless scientific studies containing water themes are release continuously. Although research can be of great help, often it only serves academia's purposes. Many times researchers forget to go out on the field to experiment in ordinary life conditions. For that reason, more practical and tangible approaches based on local context are necessary in order to contribute to the body of knowledge of water provision.

Revolutionary technical solutions for providing clean water are being developed continuously; many times these technologies simplify processes, make them cost-effective or enable clean water provision in places that were considered very challenging. For that reason, up-to-date research is needed in order to develop tailor made knowledge to meet the demands of innovative solutions that contribute to the goal of clean water provision to all.

1.2 Research Aims and Questions

Considering the aforementioned, this thesis aims to contribute to the body of knowledge of water provision by addressing the problem of lack of clean water provision systems in rural communities, taking the case study of various rural communities in Mexico.

This research aims principally: at understanding and analyzing the complex water provision system in Mexico in to rural communities, and propose practical guidelines for its improvement

In order to attain this aim, firstly this study took a general overview of the water provision system in to rural communities in Mexico, then it identified and examined key concepts and challenges for the development of water provision systems and its sustained development in rural communities.

This research project included the arrangement for the donation of a water filtering device (PAUL) donated by Professor Franz-Bernd Frechen and his team from Kassel University and other donors.

PAUL will be placed (after the submission of this thesis) in one of the communities that served as case studies, being placed within a sustained Clean Water Governance Framework based on the lessons and outcomes of the thesis. Making it another aim of this research project help address the current lack of clean water and in the near future continue to learn from its full implementation process and operation. In the following table, the research questions of this study are outlined and described:

Table 1-1 Research Questions

Research Questions	
RQ1	How is/are water provision system(s) organized in Mexico for rural communities?
RQ2	What are key elements in a successful clean water system for a rural community?
RQ3	What conditions have to be considered in order to deploy a technical device for clean water? (Learnings from research on how to best deploy PAUL)

1.3 Research Approach

This thesis investigated water systems in Mexico to address the problem of access to clean water for human consumption in rural communities.

With this background in mind, this thesis used a combination of qualitative and quantitative data and made use of data triangulation to increase confidence in its outcomes. In the following figure, the course of this research is presented.

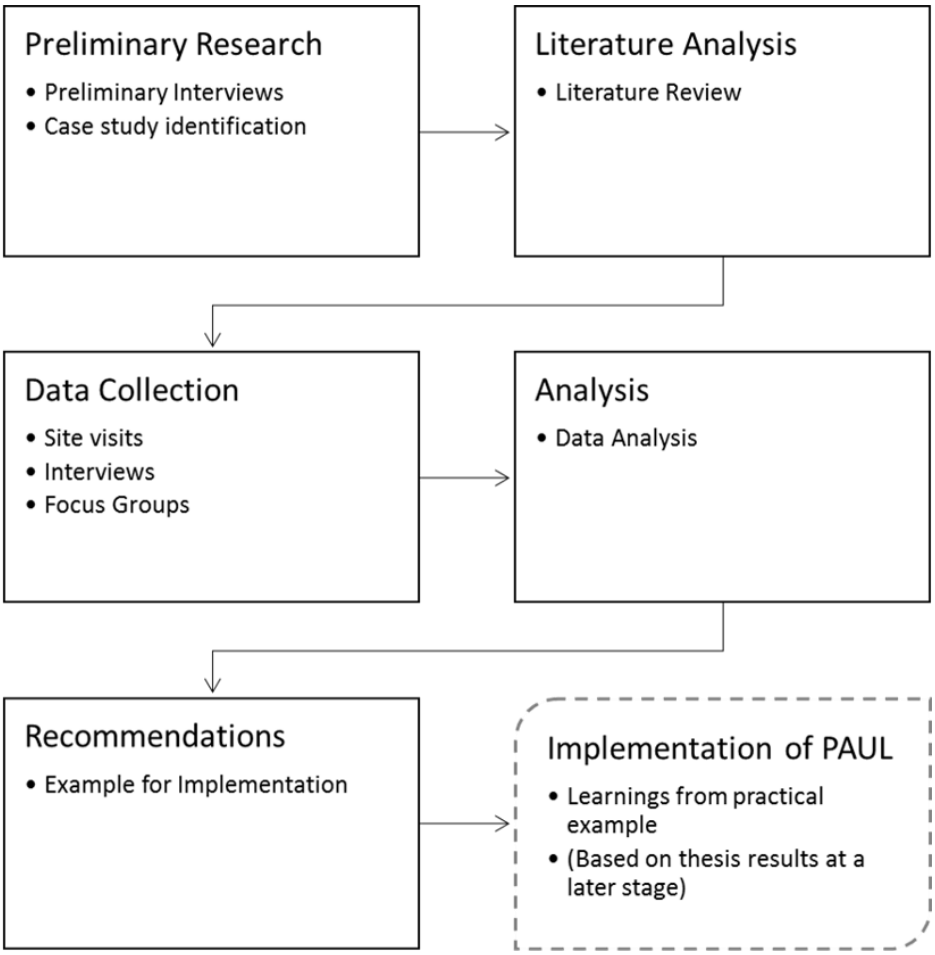


Figure 1-2 Research Course

Even though, several efforts have been done to provide clean water to rural communities in Mexico, there is still a great need of clean water in rural settings as the governing framework needs to be strengthened and at the same time new technical solutions are being developed.

1.4 Scope and Limitations

This research study concentrated in studying clean water provision in rural communities with less than 500 inhabitants, understanding that the definition of rural communities provided by INEGI refers to those communities with less than 2500 inhabitants.

The Mexican case is relevant to research because Mexico has about 200,000 rural communities (D. F. Barnes, 2007). Today about 20% of its total population live in such communities representing about 22 million people (INEGI, 2016). The case selection was based on criteria that would allow to be representative cases, thinking on replicability in similar communities.

However, one should consider that each case is different according to the characteristics from each community.

Following that, the case study of seven rural communities was selected. One of them being an indigenous community located in the southern State of Oaxaca, and six other communities in the central State of Guanajuato (see figure 3-1).

These communities were selected after a feasibility analysis derived from preliminary interviews with experts and practitioners on the field, based but not exclusively on current needs of clean water, where water purification systems have been set in place and research viability.

After the case study justification (see section 3.1), the author acknowledges that these case studies might not bring the full representation of rural communities, however the selection provides a reasonable background to research this topic. These communities can well be representative cases of rural communities around Mexico.

Enhancing water provision in to rural communities is one of the main goals to meet a sustainable development as indicated by the Sustainable and Development Goals (SDGs), particularly Goal 6, this goal includes water and sanitation provision, important to note that this study only focuses in clean water provision, while acknowledging the equal importance of sanitation.

For data collection, completeness and data integrity was in line with the research objectives to include as many as possible relevant actors, considering first an analysis of relevant actors involved in the water provision sector concerning the case study selection. Throughout the process, transparent communication of data, research gaps and/or cut-off decisions were communicated with its justification for reference and future research.

Some data for this research was unreachable or inexistent due to a number of reasons, including the possibility of unwillingness of actors involved in the water sector of making it available, despite that in in Mexico legislation mandates for data transparency of public information. Another limitation includes that some of the relevant actors were unavailable or unreachable.

This research project did not perform a technical analysis of water quality on site, however in collaboration with other researchers, it included some data on the water quality. This study did not evaluate current water infrastructure, however it included available data from firsthand information deriving out of practitioners on the field, at the same time this research was not limited to a certain technology.

1.5 Target Audience

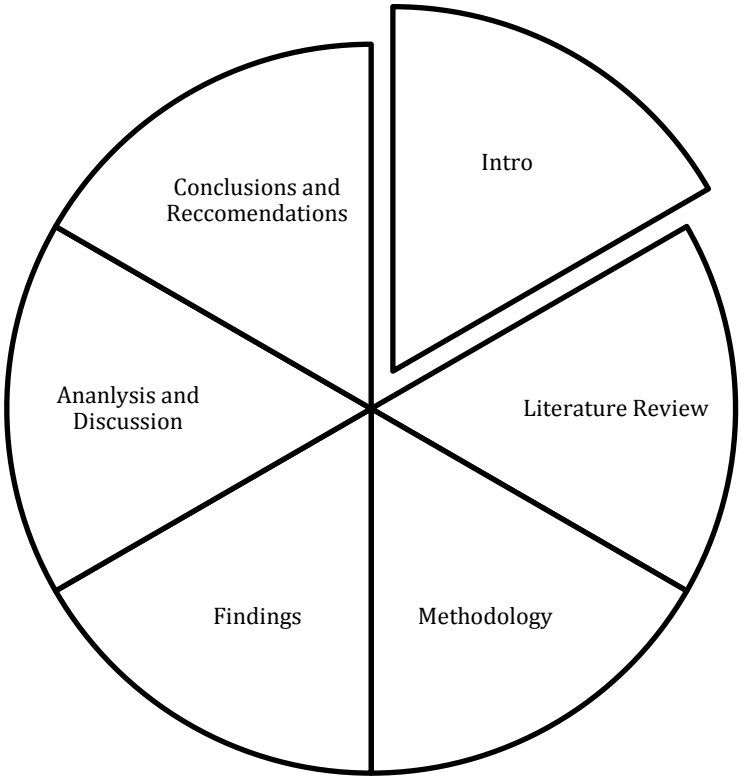
This thesis was done for the fulfilment of the Master's Degree in Environmental Sciences, Policy and Management (MESPOM). Considering all features included in this thesis, this work is supposed to be useful to different actors related to water policy and governance such as:

- Public administrators: authorities (water agencies) and policymakers specialized in provision, purification, planning, implementation, and monitoring of water provision systems.
- Researchers especially those focused on water implementation frameworks, water purification technology developers such as Kassel University´s researchers to gather information for future deployments.
- Any actor involved in implementation of water purification technologies in rural communities, such as local committees, NGOs, entrepreneurs or private companies.

1.6 Thesis Structure

This research project comprehends eight chapters, hence, for clarity and structure for the reader, this thesis is organized following this outline:

- Chapter 1 (Introduction) introduces the topic and presents the nature of the problem address in this thesis and scopes the research approach.
- Chapter 2 (Literature Review) is divided in to two parts, firstly, it briefly introduces to the historic perspective and current status of water provision in rural communities in Mexico, along with its current challenges, in order to put this study in to perspective. The second part focuses on finding a relevant conceptual framework for water provision in rural contexts accordingly to the case studies.
- Chapter 3 (Methodology) presents the methods used in this study for data collection and further analysis.
- Chapter 4 (Findings) presents the results from the data collection methods performed during this research.
- Chapter 5 (Analysis and Discussion) analyzes the data gathered in Chapter 4, and Discusses the validity of the frameworks used to meet this purpose.
- Finally, Chapter 6 (Conclusions and Recommendations) summarizes and concludes on the overall findings of this research study and provides a series of recommendations, at the same time it includes the details of PAUL and a recommendation for its installation based on the learning process from this thesis.



In the next chapter the literature review is presented.

2 Literature Review

This chapter presents the literature review pertaining to this thesis. For the sake of clarity and structure it is divided in to two main sections. The first part investigates current status of Mexican water provision in rural settings, legislation and policies pertaining to the case study selection.

The second part focuses on finding a conceptual framework to analyze the selected case studies. It revised different concepts and frameworks behind the provision of water in rural communities. During the process, the review tried to identify any gaps on existing knowledge, and took in to account different disciplines.

This method consisted on reviewing different kinds of relevant literature sources such as books, academic articles, grey literature, governmental reports and any other online tool related to the chosen topic.

2.1 Background and Context: Water Provision in Mexico

In Mexico everyone is entitled to the right of access to water and sanitation for personal and domestic consumption, in a sufficient, safe, acceptable, and affordable manner, as it mandates the Mexican Constitution in its article 4. For those purposes, the state shall guarantee this right, and the related legislation must regulate the bases for a sustained and equitable access of water.

Water legislation establishes that the three levels of government along with citizens, must get involved in the achievement of these purposes (Mexican Constitution, 2016). However, in Mexico not everyone can enjoy this right as the Constitution mandates.

Water policy requires an understanding of existing institutional settings.(Gupta et al., 2013) Therefore in the next section, a historical perspective on the water sector in Mexico takes place, aiming to identify how the institutional framework is working.

2.1.1 Historical Perspective of Water Provision in Mexico

At the middle of last century, the Mexican water resource management was highly centralized in the national government. Later on, in December 1972 a new Federal Water Act was approved that sought to regulate the exploitation and use of water belonging to the nation. This law unified the various laws relating to water. A relevant aspect is that this Act limited water concessions, and gave priority to domestic and urban use of water, over agricultural and industrial one. (SEMARNAT, 2009)

Afterwards in the late 1970s, the Mexican government initiated several structural reforms. Within these reforms, changes in law and water management were linked to the discussion of strengthening federalism. In consequence, later on there was a shift that carried the transfer of powers and functions from the federal government to states and municipalities, with the argument to enhance regional development (SEMARNAT, 2009).

In October of 1980, the Federal Government through the Ministry of Human Settlements and Public Works (SAHOP) ordered the transfer of the Water Systems to the states. At the time, this change claimed that the lack of resources and inefficiency in handling the water systems urged a changed in order to strengthen federalism (SEMARNAT, 2009).

In 1982, a national constitutional reform took place to article 115. It involved the participation of the three levels of government in a coordinated manner in the planning process, analysis and implementation of fiscal policies. As part of this reform, water services and sewerage were

allocated to municipalities, including the participation of states if necessary. The main objective of this reform was to encourage a more inclusive policy, and self-sufficiency of water and sewerage services (SEMARNAT, 2009).

In the late eighties, there was a need to have a separate organization of the water sector and its uses, thus in 1989 CONAGUA was created as a decentralized federal agency from the Ministry of Agriculture and Water Resources (SEMARNAT, 2009). Nowadays, CONAGUA still remains as the main Federal Agency involved in the water sector.

The process of decentralization has concluded and each state has its own water agency. At the municipal level, city governments must have as well a dedicated decentralized or centralized water agency, being this one the main responsible of providing clean water to its inhabitants. In the next part the current scheme of water provision is covered.

2.1.2 Clean Water Provision in Mexico: A Human Right

As it has been mentioned, in Mexico everyone is entitled to the use of water for personal consumption. In consequence, water access in Mexico is considered a human right since 2011(Diario Oficial de la Federación, 2011). That year, a constitutional reform passed and amplified the access to human rights, including all the ones encompassed in international treaties signed by Mexico (Diario Oficial de la Federación, 2011). Considering that In 2010, the UN General Assembly adopted the Human Right to water and Sanitation (Gupta et al., 2013). As well, the Mexican Constitution in its article 27th, mandates that all water belongs to the nation or else stated in legislation.

Water Legislation should be adapted to ensure this human right (Anaid Velasco, 2015), and water should prevailed to be part of the State. Yet, there have been efforts for water privatizations, going against the principles of public good and the right to access (La Jornada, 2015) (CNNMéxico, 2015) (Nayeli Roldán, 2015), as mandated by the Mexican Constitution.

This thesis uses the definition of "right to water" as: the access to sufficient water, in terms of access including the affordability of it, and enough water in terms of quantity and quality in order to have a decorous way of living (Scanlon, Cassar, & Nemes, 2004). Continuing, the next section presents how the institutional framework in charge of ensuring this right is structured.

2.1.2.1 Institutional setup for Water Provision

Mexico is organized as a federal republic composed of 32 sovereign states. The national, state and municipal levels, conform the three levels (orders) of government. Each of them have different responsibilities and specialized public bodies in charge of diverse tasks relating to water, depending on jurisdiction and associated legislation.

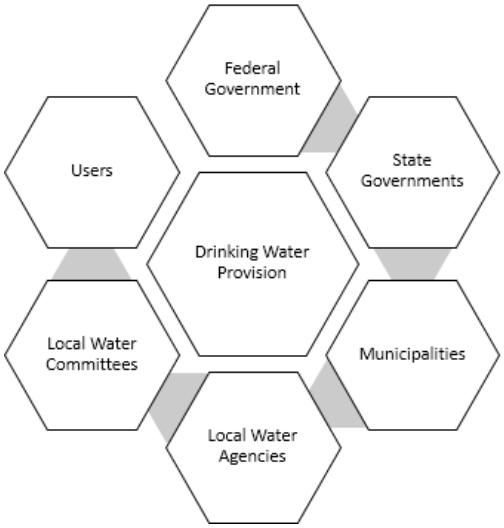
At the Federal Government, it is the CONAGUA the main agency in charge of taking care of issues related to water. The Secretariat of Budget and Finance (SHCP) is the one in charge of the planning and execution of the national budget. As well, at the federal level, there are other agencies involved with water provision, for example: SEDESOL, BANOBRAS, CDI, CONAVI. These agencies contribute to the development of water provision and sanitation, by constructing infrastructure from its diverse social programs (Federal Government of Mexico, 2014), the main functions from each agency can be seen in the following Table (2-1):

Table 2-1 Federal agencies related to water provision in Mexico

Agency	Description	Main functions
CONAGUA	National Water Commission	Preserve national waters and their inherent public goods for their sustainable management and ensuring water security with responsibility for the orders of government and society in general.
SHCP	Secretariat of Budget and Finance	Propose, manage and control economic and financial policy, spending, income and public debt to strengthen Mexican welfare.
SEDESOL	Secretariat of Social Development	Social development policy giving special attention to the most vulnerable sector.
BANOBRAS	National Bank for Public Works and Services	Boosting investment in infrastructure and public services, promote the financial and institutional strengthening of states and municipalities
CDI	National Commission for the Development of Indigenous People	CDI serves and benefits millions of indigenous families with housing and infrastructure.
CONAVI	National Commission for Housing	Design, coordinate and promote housing policies and programs in the country.

Source: (Created by the Author, based on official information from institutional websites 2016)

At the state level, the state governments along with municipalities are responsible for the planning and implementation of water projects. The state governments also gather the information for planning in their territory (Federal Government of Mexico, 2014).



As it is mandated by the Mexican Constitution in its article 115th, municipalities are responsible for clean water provision, operation and maintenance of infrastructure, and sanitation of waste water, within its territory. Municipal governments may pass on this responsibility to decentralized water agencies. Most of the time, these agencies are the ones in charge of the provision and operation of drinking Water Systems of every municipality (Federal Government of Mexico, 2014).

Figure 2-1 Institutional framework for water provision

Water users are expected to contribute to the system by paying the corresponding fees for water usage,

that allows to cover the expenses for maintenance and operation of the network.

2.1.2.2 Water provision in to Rural Communities

Historically, humans have settled where water is close to enable living conditions. It is the case of most rural villages in Mexico, they are located close to a water source, however many times communities lack the infrastructure needed to bring water to their homes, and many more times, the treatment of this water is insufficient or inexistent.

As it has been previously noted, according to legislation it is the role of municipal governments to guarantee the supply of water within their territory, however, historically speaking, there has been a lack of capacity from municipalities to ensure clean water for all. For that reason, most of communities have organized themselves and established local water committees that aim to guarantee water for all. In the next figure, the water provision system in a rural community is outlined.

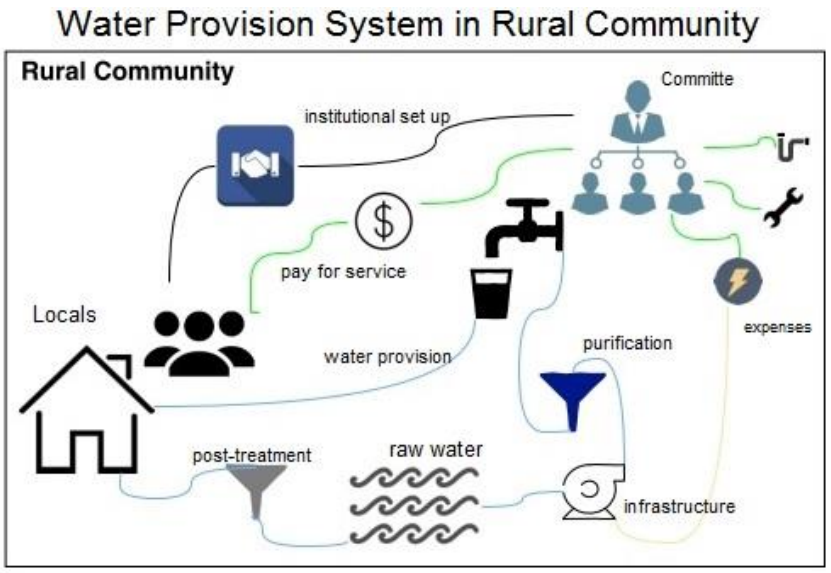


Figure 2-2 Water provision system in rural community

Due to the lack of capacity from municipalities to ensure water, the federal and state governments have been intervening with financial resources, and sometimes with direct action to tackle this public problem

Since 1996, CONAGUA implemented a Program for the Sustainability of Drinking Water and Sanitation in Rural Communities (PROSSAPYS). The aim of this program is to provide potable water and sanitation to marginalized rural communities (CONEVAL, 2016).

PROSSAPYS was born as an initiative to tackle directly the problem of water provision in rural communities. First it started as a pilot project in certain areas and as it proved to be successful it was extended nationally (Ducci, Manjarrés, Garzón, & Urra, 2010).

PROSSAPYS was partially financed by the Inter-American Development Bank (BID). It was modified through time to allocate better resources depending on priorities, depending on needs and with levels of poverty. In practice, the success of PROSSAPYS was highly dependent on the work done at the state and municipal levels, as they were the ones in charge of initiating the projects (Ducci et al., 2010).

The BID performed an analysis of PROSSAPYS, and concluded that:

- it included mechanisms to respond to the real needs of the population, and where possible projects were managed and operated by locals.
- encouraged community participation in provision of water services, and enhanced education on hygiene issues,

- it developed a sense of ownership, and an improvement in quality of life of people, as it was seen on the reduction of gastrointestinal diseases and an improved economic situation (Ducci et al., 2010).

However, the BID (2010) detected that some of the water infrastructure did not operate for various reasons, mainly because of conflict within the water committees, lack of electricity, or theft of equipment.

In order to address this weakness, PROSSAPYS considered setting in place an accompaniment team at least for the first couple of years of operation. And for that reason, the BID recommended that state and municipal water agencies, should have specialized units (departments) focused on attention to rural communities, that enabled follow up on projects (Ducci et al., 2010).

There has been good progress in the development of coverage of services in Mexico. In terms of water provision the rate went from 51,2% in 1990 to 81.6% in 2014 as seen on the figure, while one can see the prominent improvement on sewerage coverage as seen on the figure, it increased from 18.1% in 1990 to 71.2% in 2014 (CONAGUA, 2014; Ducci et al., 2010).

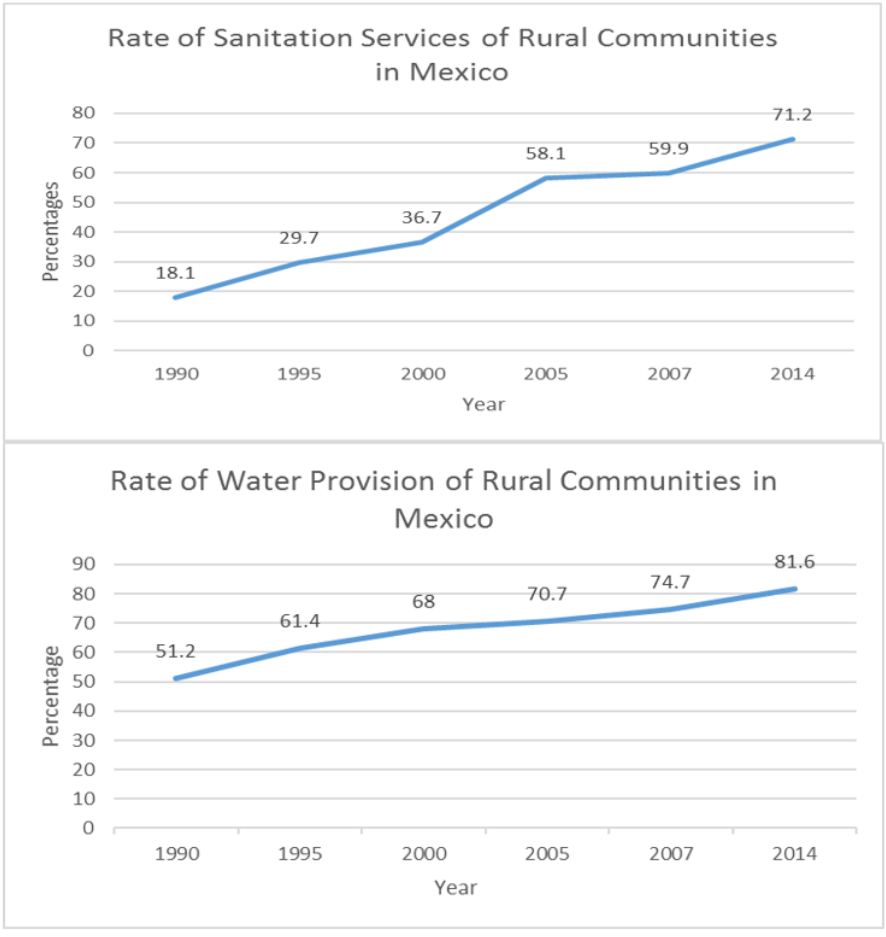


Figure 2-3 Rates of water and sanitation provision in rural communities of Mexico

Source: (BID 2010, CONAGUA 2014)

Along with PROSSAPYS, the Federal Government operated a program named "Programa de Agua Limpia" PAL (Program for Clean Water) which started to operate in the beginning of the 1990s, following a cholera and hepatitis emergency in some spots of the country. PAL focused

on the disinfection of water in urban and rural settings. The main method installed was chlorination (CONAGUA, 2014).

According to information from CONAGUA (2016), PROSSAPYS and PAL were operating until 2015, as CONAGUA decided to joint all programs related to water provision in to one program named PROAGUA arguing to enhance simplicity and efficiency of procedures. This new program, named PROAGUA, looks to tackle the demand for water provision in urban and rural areas.

PROAGUA has two sections, one to provide water to urban areas, the other to provide water to rural communities (CONAGUA, 2016). Along with PROAGUA, at the end of 2015, a new approach PROCAPTAR (program) is for isolated communities. According to CONAGUA (2016), this new scheme aims to collect rainwater and store it in a water tank in each household while purifying it, making use of innovative technologies.

Due to the above, the challenge now is to look for innovative solutions that apply unconventional technologies to ensure the functionality of systems considering economic viability.

2.1.2.3 An Agenda for Water Management in Mexico

In 2010, Mexico adopted the "2030 Water Agenda". This agenda sets an ideal vision for 2030 relating to water. The agenda outlines the current situation of the sector and visualizes an ideal scenario, while it prioritizes the lines of action to reach this scenario. It identifies areas of opportunity for change for example changes in institutional organization, planning, legislation, regulation, financing, education, capacity development among others (Santana & Martínez, 2011).

The Agenda spots some challenges for this to happen, firstly local governments must address their responsibility. There is a need to professionalize agents in charge of the sector, tariffs should be decided according to technical criteria and not from political influences, and strengthening the capacities and attributions of the National Water Commission and state water commissions to promote, supervise and regulate drinking water and sanitation services. The following figure contains the agenda framework for water management.

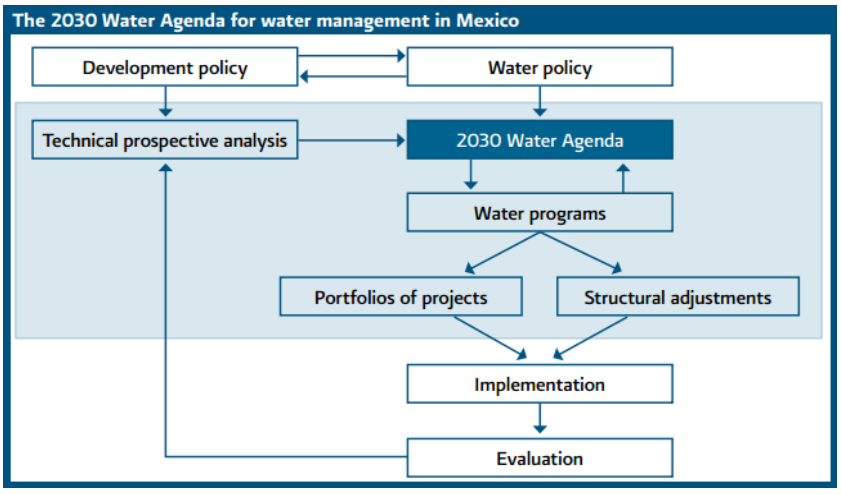


Figure 2-4 Water Agenda for water management in Mexico

Source: Adapted from (SEMARNAT 2010)

2.1.3 Current and Future Challenges in Providing Clean Water in Mexico

There are many challenges related to the provision of clean water especially in rural communities in Mexico. These include insufficient CWPS, water scarcity, contamination, poverty eradication, among others. In the following table these challenges are presented.

Table 2-2 Current and future challenges in providing clean water in Mexico

Challenge	Description
Insufficient CWPS in rural areas	One of the main challenges is the insufficient distribution in water in Mexico. According to CONAGUA in 2014, about 20% of total rural-households lack access to drinking water
Water Scarcity	In Mexico, there are large differences in water availability. Central and northern areas of Mexico are, for the most part, arid or semi-arid: and in the south they get almost half of rainwater (49.6%), hence the southern part gets half of total rainwater (CONAGUA, 2014). The expected negative effects of anthropogenic Climate Change pose challenges in the water sector worldwide (Stocker et al., 2013). In Mexico, these challenges come from enhanced natural disasters and a series of droughts throughout the Country. Montes-Rojas et al discussed some adaptation measures to be implemented to address these challenges (Montes-Rojas, Ospina-Noreña, Gay-García, Rueda-Abad, & Navarro-González, 2015). Important to know is that according to CONAGUA in 2014, about one sixth of all aquifers in Mexico were considered to be over exploited. For the case of Mexico, Montes Rojas et al., claim that water availability per capita has fallen by 66% in 50 years, and it is expected to continue decreasing if current population and precipitation trends continue. For that reason, they suggest to implement water conservation strategies across economic activities (Montes Rojas, 2015).
Water Contamination	INEGI (2010) reports that major Mexico faces major water pollution problems, concentrated in diverse areas of the Country. For instance, Montes-Rojas et al. state that in some regions in Mexico, arsenic and fluoride are naturally in groundwater. It has been spotted in wells located in Guanajuato, Zacatecas, Oaxaca, Morelos and Puebla (Montes-Rojas, Ospina-Noreña, Gay-García, Rueda-Abad, & Navarro-González, 2015; Ortega-Guerrero, 2009). The World Health Organization (WHO) recommends a maximum concentration for arsenic in drinking water of 0.01 mg/L. In Mexico, the official norm (NOM) has set a maximum limit of 0.025 mg/L (NOM 2000). Whereas, in the case of F, the maximum limit recommended by the WHO and adopted by Mexican standards is 1.5 mg/L (WHO, 2004).

Eradicating Poverty	Eradicating poverty is one of the major challenges that Mexico faces today; estimations suggest that about 50% of people live under some type of poverty condition (CONEVAL, 2016). Water accessibility has a lot to do to face this problem. The current National Water Plan 2014-2018 states as one of the priorities to enhance water and sanitation provision as one of the strategies to tackle poverty.

This section portrays that there has been good progress in terms of provision of water in Mexico, however, many challenges still remained as close to one fifth of households in rural communities continue to lack access to water, and many of the ones getting water, it may be lacking drinking quality.

2.2 Concepts for Clean Water Provision

This section identified different concepts and challenges relating to the provision of clean water focusing in rural communities. The aim was to understand water provision systems from different perspectives and to build a framework based on the concepts of sustaining water provision systems to analyze the findings of this thesis.

As obvious as it may seem, the most important thing for any water provision system is water itself. As mentioned previously, the WHO recommends at least fifty liters of clean water to every person on a daily basis, in order to maintain their health and for sanitation purposes. Although one must think that 50 liters is the minimum recommended not the ideal one.

A report by the OECD (2011) agrees that there is enough water for all on earth; the main problem is the mismanagement of it. Consequently, water systems face a series of diverse challenges that should be overcomed to improve water provision conditions.

2.2.1 Challenges for Sustaining Water Systems

In order to jump in to the concepts, one must understand the detected problematic in the praxis relating to the implementation and operation of water provision systems. Barnes et al (2011) estimate that at any given time about 30 to 60 % of existing water systems are not operating. Water projects can fail for a number of reasons including, local conflict, misanalysis of context, poor technical conditions, deficiency of training, and lack of government involvement (R. Barnes, Roser, & Brown, 2011).

Another report by UN-Water (2006) concludes that often the lack of basic services such as water is due to mismanagement, corruption, unsuitable infrastructure, lack of investments, bureaucratic inertia and appropriate institutions, hence by improving governance the chances to overcome poverty and achieve sustainable development increases (UN-Water, 2006).

Da Silva et al identified (2013), that once outsiders leave the community, there is a tendency for conflict to start, threatening the long-term success of the project. However, after doing some satisfaction surveys, mostly all of inhabitants were satisfied with water projects and stated that their quality of life had improved after the implementation of such projects.

A group of experts sponsored by the World Bank held a series of meetings known as Cusco+10 (1999, 2010) to identify challenges and best practices in water and sanitation projects in rural areas of Latin America.

They identified 5 main challenges to be acknowledge for the present decade and these are:

1. Seek sustainability for basic rural sanitation
2. Think beyond the project cycle with the demand based approach.
3. Maximize the process of decentralization in municipalities.
4. Promote consistency and alignment between national and international cooperation.
5. Encourage long term monitoring to insure sustainability of the projects. (Glenn, P.-O., 2011)

Project follow-up and lack of financial support are key elements for failure. For that reason, municipalities should monitor and control projects, for technical and for financial assistance, they should budget for such attentions (Glenn, P.-O., 2011).

2.2.2 Sustaining Water Provision Systems

Enhancing participation is encouraged during the project cycle and beyond in order to promote local partnerships and to find a balance between the time needed to build infrastructure and social conditions for better results (Glenn, P.-O., 2011).

Barnes et al. (2011) signaled the importance of a strong community participation, community demand for improved services, to consider sustainability criteria in the process of planning, and another significant factor the level of commitment of stakeholders (R. Barnes et al., 2011).

In order to overcome the tragedy of the commons, Ostrom et al. set a number of principles for successfully governing common pool resources. For that reason, governance should employ a mix of institutional types, including community self-governance, and to make use of decision rules, increase information, to monitor the use, and induce compliance with the set of rules. And they argue that: science can help design appropriate adaptive institution frameworks, accordingly to specific contexts. However, they recognize that science alone, will be insufficient to tackle this challenge (Dietz, Ostrom, & Stern, 2003).

Ongoing support for ensuring success is another key element of water systems and also the level of involvement of the different levels of government considering their capacity and already present authority in the region. (R. Barnes et al., 2011)

Local authorities have the advantage of a direct contact and knowledge of local context, therefore, they should insure the promotion of water services to guarantee demand, to provide technical assistance to repair and maintained facilities and finally to constantly monitor the systems (Glenn, P.-O., 2011).

A crucial part of water provision systems is the self-sustaining of systems, someone has to pay for the related costs (R. Barnes et al., 2011). Water projects should be self-financed when possible, the involvement of municipalities is suggested as they have more capacity to support such projects than the local committees (Eneas da Silva, Heikkila, de Souza Filho, & Costa da Silva, 2013).

Cusco+10 suggested six guidelines for water systems in Latin America:

1. To develop a legal framework that regulates with a comprehensive vision.
2. To offer several solutions to address specific demands while avoiding a one-fits-all solution.
3. Promotion of low water use technologies to encourage people to save water.
4. Consideration of private participation in the provision of water services.
5. Inclusion of environmentally sound solutions.
6. To link the improvements to possible new economic activity in the region, such as tourism(Glenn, P.-O., 2011).

Clear goals and monitoring systems are recommended to be incorporated in to water models (Hamstead, 2009). Many times, locals do not have access to decision making and lack valuable information leaving them without the capacity to act (UN-Water, 2006).

Peltz suggests to take in to account key elements such as the physical environment, social and political conditions, economics, access to development aid and community participation, in their project they conclude that it was great help to work closely with a community in El Salvador to take key information (Peltz, 2007). Chantler suggests a project development cycle for water supply projects, it starts with a planning phase, it continues with the implementation and finally with its operation phase, at the same time he suggests to set short, medium and long term goals for the project (Chantler R.A., 2005).

In terms of policy, policy making for water projects should be treated differently from urban and rural contexts. Policies should be clear and concise, prioritize for the disadvantaged (creation of subsidies), apply a good regulatory framework that allows the consolidation of institutional frameworks, and finally to apply the best technological solutions based on the local context (Carrasco Mantilla, 2011; Jouravlev, 2004)

Sara & Katz studied if water-supply services that are demand-responsive are more sustainable than those that are not. Their research included ten projects in the developing world. They defined demand as *the quantity and quality of water community members will choose to consume at a given price*. They state that demand is important because the demand from users indicate the willingness to conserve in operation water units. They add that there are key aspects for determining so, one is the prioritization understood as participation from community to seek better services, willingness to pay for the service provided comes second, and finally to make informed decisions understanding their implications (Sara & Katz, 2004). Finally, they conclude that sustainability is higher in communities when projects followed a demand-responsive approach. They suggest that household users should be the ones be making choices, as it has proven to ensure sustainability. As well they recommend training the final users to build capacity and commitment, and that quality of the works should prevail to ensure sustainability (Sara & Katz, 2004).

2.2.3 Water Governance

There is a number of studies relating to governance. Good governance is a crucial element in terms of the development of any state. As governance can provide a conceptual framework to better understand the relationships among different sectors and stakeholders in the way problems are addressed in any society (Franks & Cleaver, 2007).

Rogers and Hall (2003) define water governance as: *"the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society"* (Rogers & Hall, 2003).

Franks & Cleaver generated an analytical framework to describe the way arrangements are made in water governance and their impact on the poor (people). Such framework includes key concepts such as: resources which are described as the "*range of materials and non-materials from which human interaction and social structures are constructed" (Franks & Cleaver, 2007)*. They continue to argue that they adapted this "resources" concept to water governance to include power relations, structures of inequality and resource allocation (Franks & Cleaver, 2007). Continuing with their framework, they state another term "mechanisms" which are contextualized as the mediators or formal institutions that participate in the process. Consequently, they define the term "outcomes" which are the impacts produced from water governance mechanisms. They also include the term "processes" which can be understood as the activities related in terms of

negotiation, decision-making and acting. They continue and describe the term "agents" which are the actors who facilitate "processes" within this framework (Franks & Cleaver, 2007).

Franks & Cleaver conclude to define water governance as "the system of actors, resources, mechanism and process which mediate society's access to water" (Franks & Cleaver, 2007). Their study was based on a local scale, and suggests further research in larger scale governance frameworks. They conclude that water and sanitation sector should aim to address two principal objectives, poverty eradication, and environmental sustainability (Franks & Cleaver, 2007).

The OECD (2011) suggests guidelines to encourage and integrated public governance of water policy and these include:

1. Clearly define roles and identify gaps across levels and public agencies.
2. Involve local governments in planning considering their important role in implementation.
3. To adopt horizontal and coherent governance tools and enhance cooperation across public agencies.
4. To harmonize and update Water Systems databases
5. Encourage monitoring and evaluation of outcomes
6. Encourage and inclusive approach through public participation
7. To assess governance instruments

Dominguez Serrano (2007) suggests that water governance should take in to account improvements in institutional capacity, legal frameworks, sharing of resources, and the decision making process around water and roles of power among stakeholders. As well, Governance should include elements of: public participation, accountability, effectiveness and coherence (Domínguez-Serrano, 2007). Water governance should involve, "integrated water resource" and "watershed management", as forms of effective management. Water governance should also include: the recognition of traditional practices (customs) of local areas, such as indigenous communities, as many of them experience a appraisable coexistence with nature (Domínguez-Serrano, 2007).

Rural water governance can present problems of free riding and overuse leading to common pool resources problems. Collective action and self-governance are key drivers for the community to maintain and operate water infrastructure, as well as setting and enforcing their own rules(Naiga, Penker, & Hogl, 2015).

UNDP (2005) signals that good water governance is a complex process, that is influenced by the general principles of governance of the country, its customs, traditions, policies, conditions, and the evolution of the global economy. UNDP concludes that there is no perfect plan for good water governance but successful elements in all of them (PNUD, 2005).

2.2.4 Elements for Sustainable Water Policy

Sustainability is an essential aspect for water provision systems. Sara & Katz define sustainability based on water projects such as *"the maintenance of an acceptable level of services throughout the design life of the water supply system"* (Sara & Katz, 2004).

According to the Environmental Quality Board (EQB) from Minnesota, water sustainability and availability are related, they define water availability as *"the amount of useful water in the hydrological system"* and water sustainability refers to *"the understanding the ability of the hydrological cycle to meet people's need and safeguard ecosystems for the indefinite future"* they continue to add that sustainable water management is about collecting information and use it to understand the environment, and match human needs with a sustainable framework (E.Q.B., 2008) suggests the use of good

indicators. They recommend maintaining a quality-monitoring network, to set up a long-term strategy for effective management (E.Q.B., 2008).

Community management is one of the major approaches for the implementation of water in rural contexts (Amer, 1986). It was developed as the major way to implement water, during the decades of 1970s and 1980s. In brief, this model achieved sustainability by setting rural communities to manage their own water sources. Models for supplying water in rural contexts should contain elements of sustainability, in order to avoid the mistake of not consulting with locals, and adjust the model to the local context (Amer, 1986).

Water sustainability should include elements that address the continuous hydrological system´s ability to meet human´s needs, and at the same time the protection of ecosystems(E.Q.B., 2008). At the same time, sustainable water management requires interconnected information systems to manage data, that allows for planning, monitoring and organizing Water Systems (E.Q.B., 2008).

2.2.5 Development of Water Purification Solutions

There is a range of solutions to purify water, from simple solutions that have existed since ancient times to a number of high technical solutions. A review by several water experts on water purification technologies, indicates that technologies are constantly developed to improve the means of purifying water(Shannon et al., 2008). The main challenge that water purification technologies face today is to purify water with the less effort to operate, a minimum amount of energy, and to be chemical free, along to minimize the associated costs of engineering, and operation (Shannon et al., 2008).

At the same time the number of contaminants are increasing in water sources used for human consumption. Contamination of water sources include, heavy metals, distillates, and endocrine disrupters known to cause harm to humans and the environment. Decontamination to remove such toxic elements, can be costly and technically challenging (Shannon et al., 2008).

2.2.6 Linking Concepts for Sustaining Water Systems

As seen previously, there is plenty of literature regarding how water provision should be frame. Many articles have developed guidelines and frameworks on how to implement and sustained water systems in rural communities.

For that reason, this section tries to gather from the previous revised literature, relevant conditions for sustained (successful) water provision systems in order to develop a framework for analysis according to the findings of this thesis.

First of all, as drawn from the literature, there is not one model that fits all cases, or that helps overcome all obstacles for water governance frameworks (Gupta et al., 2013).

Based on the revised literature, I would like to focus on the work from Rebbeca Barnes, David Roser, and Paul Brown. They (2011) embarked on a research project to determine the key attributes of frameworks of water systems in rural communities. They investigated over 100 documents in order to identify key elements, and provide guidance to those seeking to use them. In the process, they selected 17 frameworks from literature and recommendations from practitioners. A number of recommendations from the studied frameworks were portrayed along their research. According to their conclusions from analyzing frameworks, they concluded on the importance of strong community participation, involvement of government, sustainability criteria in planning, self-financing of water systems, and accurate assessment of local context (R. Barnes et al., 2011).

2.2.6.1 Framework for Analysis

As a result, the author of this thesis selected a series of conditions from the previously revised literature in order to create a framework for analysis, acknowledging that each condition´s importance, presence, or relevance, might differ from case to case.

First condition, **Community Engagement**, this refers to that community members are sufficiently engaged in the clean water provision system (CWPS), and that there are sufficient "mechanisms" in place for equity in participation and contribution of all actors (R. Barnes et al., 2011; Dietz et al., 2003; Franks & Cleaver, 2007; Glenn, P.-O., 2011; Naiga et al., 2015).

Second condition, the **Involvement of Government**, this refers to the level of Government's involvement in all phases of the CWPS. And as well, there is a liaison between local inhabitants and local government (R. Barnes et al., 2011; Glenn, P.-O., 2011)

Third condition, **Sustainability of Water Provision System**, this refers to see if CWPS includes a holistic approach in terms of sustainability, as described on the revised literature (Amer, 1986; R. Barnes et al., 2011; E.Q.B., 2008; Franks & Cleaver, 2007; Sara & Katz, 2004).

Fourth Condition, **Consolidation of Responsible Local Actors,** this refers to the presence and consolidation of local responsible agents in the management, operation and control of CWPS (R. Barnes et al., 2011).

Fifth condition, **Accurate Assessment,** this refers to perform an accurate assessment of the social, economic and environmental aspects and as well as of technical conditions in all CWPS phases (R. Barnes et al., 2011; Dietz et al., 2003; E.Q.B., 2008; Glenn, P.-O., 2011; Hassing, 2009)

Sixth condition, **Self-Financing**, this refers to the presence of mechanisms for self-finance, such as water fees for the operation and management of the system (R. Barnes et al., 2011; Eneas da Silva et al., 2013; Glenn, P.-O., 2011).

Seventh condition, **Regulatory Framework,** this refers to the presence of formal or informal regulatory frameworks that enable the operation of the CWPS, contemplate conflict resolution and allocation of responsibilities (Dietz et al., 2003; Glenn, P.-O., 2011).

Eight condition, **Technical Conditions**, this refers to that the CWPS has appropriate technical solutions in place that ensure sufficient and clean water and (most) users accept and use it (R. Barnes et al., 2011; Carrasco Mantilla, 2011; Dietz et al., 2003; Glenn, P.-O., 2011; Shannon et al., 2008).

Ninth condition, **Training and Education,** this refers to that there have been enough informative talks and trainings about the operation, maintenance and importance of clean water (R. Barnes et al., 2011; Sara & Katz, 2004).

Tenth condition, **Effective Control and Follow-up**, this refers to that there is a constant and effective control and monitoring of all relevant aspects of CWPS by responsible agencies or stakeholders (Dietz et al., 2003; E.Q.B., 2008; Glenn, P.-O., 2011; Hamstead, 2009).

A table containing these ten conditions is presented in Section 3.2. In the next chapter, the methodology is portrayed.

3 Methodology

As introduced in Section 1.2, this thesis uses a series of methods to address its objectives, firstly, it introduces how the research was structured, then it presents the data collection methods, finally, it provides the approach on how data was analyzed.

A series of preliminary interviews with experts on the field took place looking to get an understanding on how to best address these research´s objectives as described along in sections 1.2, 1.3 and 1.4.

Most of the interviewees agreed that the topic of clean water provision is still a challenge, especially in rural communities in Mexico. For instance, Maria Perevochtchikova, suggested guidelines and recommendations according to her research experience with rural communities. (Perevochtchikova, M, personal communication, January 2016).

Jessica Gamez, a former MESPOM student, as she had done her master thesis on a similar topic recommended me how to address the problem, and remarked research gaps on the subject. As well, she suggested using different conceptual frameworks for the analysis of this research's findings (Gamez J., personal communication, January 2016).

Francisco Garcia, a former mayor of Tarandacuao (a municipality of Guanajuato State), described how the institutional framework for water provision works in practice, portrayed in later in this chapter (Garcia F., personal communication, January 2016). Prudencio Garcia, a former treasurer of Acambaro´s Water Agency, described some of the challenges faced today by municipal water agencies, such as financial and technical capacity (Garcia, P., personal communication, January 2016).

Finally, José Moran, a former Head of SIMAPAG, described the main challenges for clean water provision in rural communities, and he identified some of the communities he knew had an urgent need of clean water provision located in "La Sierra de Santa Rosa" in Guanajuato Municipality (Moran J., personal communication, January 2016). All the above was done to get a better understanding of the problem from the perspective of practitioners and researchers in order to better develop this methodology.

3.1 Case Study Selection and Justification

Considering all the above, the author selected seven rural communities as case studies. One of them being an indigenous community located in the southern State of Oaxaca, and six other communities in the central State of Guanajuato. The name and location of each community is shown on the next table:

Table 3-1 Communities selected for case studies

Rural Community	Municipality	State
San Antonio del Barrio (SAB)	San Felipe Usila	Oaxaca
Picones	Guanajuato	Guanajuato
El Terrero	Guanajuato	Guanajuato
El Laurel	Guanajuato	Guanajuato
Terreros de la Concepción	San Luis de la Paz	Guanajuato
Los Pirules	San Luis de la Paz	Guanajuato
La Cinta	Dolores Hidalgo C.H.N.	Guanajuato

The geographical aspect was selected, as Oaxaca is one of the States that lacks the most access to clean water provision (CONAGUA, 2014). Although the case of Guanajuato is not as bad it is also relevant, and the author was based there, and had access to local information that facilitated and enhanced this research (see Figure 3-1 for geographical location).

Maria Perevochtchikova, suggested visiting San Antonio del Barrio (SAB), a rural community with about 200 inhabitants part of the Municipality of San Felipe Usila (pop. 11,500) located in the northern mountain range of Oaxaca, in the watersheds of the rivers Usila and Valle Nacional located in the Papaloapan Basin. This community is quite isolated and takes a long time to reach it by road as it can be in bad conditions as confirmed during the research field trip.

Figure 3-1 Location of the states of Oaxaca and Guanajuato

Source: (Created by author using ArcGIS, May 2016)

In Guanajuato, another State, and after talking to experts from the Water Municipal Agency of Guanajuato (SIMAPAG), three rural communities were selected as case studies. During this time, the Rotary Clubs from Ashland and Guanajuato together with SIMAPAG were encouraging projects for water provision in the selected communities.

These communities are located in the "Sierra de Santa Rosa" within the Municipality of Guanajuato. These communities are Picones with approximately 65 inhabitants, El Terrero with about 255 and El Laurel with about 100 people. All of them presenting high marginalization (poverty) conditions according to data from the Mexican National Ministry of Social Development (SEDESOL, 2016).

Later on during the research process, the author was invited by CEAG to visit other three rural communities in the northern part of the State of Guanajuato, which have diverse water purification solutions set in place. All the above was done to get a better understanding of the problem from a local perspective, acknowledging that this selection may not fully represent rural communities in Mexico.

3.2 Framework for Analysis

As it has already been mentioned in Section 2.2.6 of this thesis, a number of conditions for sustaining water systems were taken from literature. In the next table this framework is presented, for more detailed information refers to Section 2.2.6.

Table 3-2 Conditions for a sustained clean water system

	Condition	**Description**
1	Community Engagement	The community is sufficiently engaged in the CWPS, there are "mechanisms" in place for equity in participation and contribution of all actors.
2	Involvement of Government	Government is actively involved in the Clean Water Provision System (CWPS) There is a liaison between locals and local government.
3	Sustainability in Decision-Making and Planning	The CWPS includes a holistic approach in terms of sustainability during planning and operation.
4	Consolidation of Responsible Local Actors	The CWPS includes locals in the management, operation and control of the system.
5	Accurate Assessment	An accurate assessment of the social, economic and environmental aspects as well as technical conditions is considered when planning for the CWPS.
6	Self-Financing	The CWPS includes mechanisms for self-finance, such as water fees for the operation and management of the system.
7	Regulatory Framework	A formal or informal regulatory framework that ensures the operation of the CWPS, allows for conflict resolution and allocation of responsibilities.
8	Technical Conditions	The CWPS includes technical solutions that provide sufficient clean and drinkable water and users accept and use it.
9	Training and Education	Enough informative talks and training about the operation, maintenance and importance clean water has been in place.
10	Effective Control and Follow-up	There is a constant and effective control and monitoring of all relevant aspects of CWPS by responsible agencies or stakeholders.

3.3 Data Collection Methods

In order to obtain pertinent data to fulfill the aims of this thesis, the following methods for data collection were used.

3.3.1 Site Visit Observations

Observation can help to get a perspective from local scenarios. This method aimed to gather relevant preliminary data on selected case studies. Visits were made according to available resources, cooperation with other researchers and institutions, and availability of stakeholders. The aim was to get an overview of the situation and perform data gathering.

First, the community of San Antonio del Barrio was visited during the month of March 2016, along with a group of scholars from different institutions of higher education in Mexico, carrying out research work on environmental payment services in the area.

Communities in Guanajuato were visited at different dates within April and May 2016 along with relevant stakeholders including researchers from Universidad de Guanajuato carrying out work on watershed management, and different personnel from CEAG and SIMAPAG (see Figure 3-2) such as hydrologists, engineers, chemists, all carrying out work to improve water conditions. Each case was different and the research was carried at different dates.

Figure 3-2 Perspectives from site visits

Source: (Photos by the author, April 2016)

During site visits, a series of photos were taken by the author in order to give perspective to the reader, and better illustrate and document the research cases. A smartphone (Honor 6) was used for this purpose. Notable pictures are portrayed along the thesis.

3.3.2 Interviews

Interviews can be a valuable method to gather qualitative data. For the purpose of getting relevant data the context where the interview takes place should be kept in mind. The author acknowledged this factor, and therefore, took a practical approach, most of the interviews developed as conversations in semi-formal settings following a predefined set of issues for discussion.

After identifying relevant stakeholders, during the site visits, a number of them were contacted for interviews. Interviews included questions about current water provision, regulation, monitoring, operation and present challenges for the delivery of drinking water. Most of the facilities of water provision in the selected communities were visited, and informal interviews were conducted with the local water committees (if existent) in charge of providing water. These interviews included questions related to the water quantity, quality, management and technical capacity. At the same time, during the site visits observations were conducted.

Some of the information provided during this process proved to be sensitive, therefore as an ethical consideration all responses were kept to a rational degree of anonymity unless interviewees manifested full consent for its public disclosure. Key notes from interviews were transcribed in the research field notebook.

Table 3-3 List of Interviewees

Actor	Institution	Role	Date (2016)
Interviews in Oaxaca State			
Angel Martinez	Comisionado de Bienes Comunales	Head of Community Assembly in Oaxaca	March
Angelica N	Health Center at Community	Head of Health Center	March
Members of the General Assembly	Members of the General Assembly and Tourism Board	Management team	March
Water Users	Local Inhabitants	Water users	March
Interviews in Guanajuato State			
Aaron Zamora	SIMAPAG (Planning Department)	Head of Department	April
Maria Rangel	SIMAPAG (Rural Communities Attention Department)	Head of Department	April
Andrés Aguilar	CIATEC (Technological Solutions)	Researcher	April
José Esparza	CIATEC (Technological Solutions)	Researcher	April
Juan Martinez	JMPASF (Technical and Operations Department)	Head of Department	April
Angelica Casillas	Former General Manager of Guanajuato´s Water State Council and current member of Congress.	Expert and Former General Manager	April
Concepción Gutierrez	CEAG	Head of CEAG	April
Joel Alférez	CEAG (Agency Strengthening Department)	Director of Department	April
Francisco Celio	CEAG (Legal Department)	Head of Department	April
Monica Chowell	CEAG (Purification Solutions)	Head of Department	April, May
Water Users	Local Inhabitants	Water Users	April, May

To gain perspective, a number of stakeholders were consulted throughout the course of the project. They provided insights into institutional and local policies and key knowledge. While it is not possible to list the extended details of each interview and interviewee, the author appreciates their time and contributions to this research project.

3.3.3 Surveys

The purpose of using this method was to gather qualitative and simple quantitative data, in order to analyze current water provision and related conditions, as well as to have enough data to decide where the further implementation of PAUL will take place.

Questions in the surveys are designed to gained perspective on water provision conditions, culture for paying for water service, problematic of water borne diseases, and housing conditions. Attached to the appendix is a sample of a survey used during this research.

This activity was carried out in "San Antonio del Barrio, El Terrero, Picones and El Laurel" along with site visits. The survey targeted a random sample (10 samples per case), a face-to-face method was performed using questionnaires.

3.3.4 Focus Group Activity

Focus groups can help to get collective information about an unknown topic to get a better understanding of it. This activity was mainly carried out to obtained pertinent data that could be used for the further implementation of PAUL.

For this reason, two semi-structured focus group activities took place in order to gather data such as concerns, opinions and views from the local water committee, and interested stakeholders about the implementation of PAUL, in order to address the current drinking water problem.

During the course, the author played a moderating role during the process. Keynotes from these activities were recorded in the field research notebook. For further details and results from this activity, please refer to section 4.3. The data obtained is portrayed throughout the thesis.

3.4 Data Analysis

Concerning the methods used for data analysis, they were analyzed according to the conceptual literature presented in Chapter 2. After the analysis of research findings, a discussion on the robustness of the framework used in this thesis was done following intensive discussions with the supervisors of this thesis. Through Chapter 5, specific data and details in to the methods was provided in the same section for clarity and structure purposes.

In the next chapter, the findings of this research are presented.

4 Findings

This chapter presents the findings of the research performed by this thesis. For the purpose of clarity and structure, the information is divided relating to the methods for data collection and the different case studies, as previously indicated in the methodology section.

4.1 Interviews

This section presents the findings from diverse semi-structured interviews with water experts and practitioners on the field working in the Mexican water sector.

4.1.1 Research Center for Innovation and Technology: CIATEC

CIATEC is a national research center based in Leon, Guanajuato. It focuses in industrial development, and in the improvement of the quality of life of society through science, technology and innovation targeting sustainability.

Andrés Aguilar and José Esparza, both researchers and water experts at CIATEC were interviewed jointly. Their main answers are presented in the following list:

- Both of them coincide that Mexico faces many challenges related to clean water provision, mainly in rural areas. In some areas, water scarcity has been evident specially in 2011 when there was a crisis due to lack of rain.
- They suggest that current water policy is mainly focusing in medium-to-large urban settings.
- There is a problem of irregular-housing development in cities and rural areas, where people builds houses without acquiring the right permits that guarantee access to basic services leading to disordered situations. They signaled that Legislation is very clear when new developments are going to happen, however, irregular practices such as corruption or bribery practices take place and allow irregular-housing to be build, thus, it is fair to say that regulators lack the capacity to prevent irregular developments.
- Many "municipal agencies" (the responsible bodies) are unable to provide clean water to rural communities due to the lack of technical and financial capacity.
- In terms of water contamination, they coincide on how hard it is to remove heavy metals from water, as high-tech solutions are expensive and many times unavailable for water users.
- People living in poverty conditions cannot afford expensive water purification units, therefore, many times water users prefer to prioritize in other things before purchasing clean (bottled) water.
- Acceptability of new solutions and technologies has been observed as a relevant issue. Technical problems from equipment has been observed, for that reason they recommend to build technical capacity along with installation of projects.
- They recommend to do pilot projects on the field, in order to explore which technologies work best under different conditions.
- Water users should pay water fees according to their financial capacity, hence, the collected money allows for the operation and maintenance of water systems.
- Andres and José were introduced to PAUL, they agreed that according to its specifications it would be a viable solution for providing clean water in the Mexican rural context. (Aguilar A., and Esparza J., personal communication, March 2016)

In the next section, findings from interviews to some government agencies are presented.

4.1.2 State Water Commission of Guanajuato: CEAG

The State of Guanajuato faces a challenge to provide clean water to all its inhabitants. The State Water Commission of Guanajuato (CEAG) is one of the main stakeholders to help address this task. For this reason, a series of semi-structure interviews took place during the months of April and May 2016, to different personnel from CEAG. The main findings are presented in the following paragraphs. As some of the information proved to be sensitive responses are kept anonymous.

- There are a number of contaminated water wells with toxic elements in Guanajuato, mainly with arsenic and fluorides. Full details were unavailable. In order to address this problem, some actions have been taken such as the placement of purification units.
- Some areas of Guanajuato are threatened by water scarcity due to the present overexploitation of aquifers.

- Challenges are mainly related to the financial and technical capacity of water agencies. Issues have been detected in many projects; projects get paralyzed for several reasons, lack of planning, permits, and lack of participation.
- Many water users in rural communities do not want to pay for their water service, or many times they do not want any government´s intervention.
- An important task that CEAG is doing, is to perform a general assessment on site before the implementation of any water project. For this purpose, they have a special department dedicated to this task. This process can be slow and highly bureaucratic.
- Many times, the lack of coordination between agencies diminish the capacity of projects to flow. As well, conflict was detected due to political disputes on water projects.

- Cooperation and concurrence among water agencies across levels of government greatly helps to achieve the success of CWPS.
- Following media reports signaling water contamination problems in rural communities, CEAG is trying to push clean water provision in rural communities as a priority.
- Finally, technical solutions for water purification should be cost-effective, simple to operate and durable (CEAG, personal communications, May 2016). (The photo is from one of the interviews performed at CEAG during the research course).

4.1.3 Municipal Water Agency of Guanajuato: SIMAPAG

The Municipal Water Agency of Guanajuato is the main body responsible of providing water to all the inhabitants in the municipality as mandated by the Mexican constitution, however, this does not occur in practice.

For that reason, a series of research activities took placed along SIMAPAG's officials. These included semi-structured interviews with members from the Departments of Planning and Rural Attention. The main findings are presented as follows:

- A demand-based approach has help as a good driver to increase water provision.
- SIMAPAG, suggests to implement an Integrated Water Strategy that contemplates all phases of water provision including post treatment, in order for it to be a sustainable solution.
- SIMAPAG lacks the financial and technical capacity to provide water solutions in isolated rural areas.
- Priority is not given to rural communities, because they are too isolated, making it very costly and complicated to set conventional infrastructure in place. However, sometimes SIMAPAG sends out water trucks (as the one seen on the picture below) to provide water.
- Some of the main challenges in order to guarantee clean water provision include, conflict among locals, the lack of financial and technical capacity of local water committees, for example if a water pump breaks down, it takes weeks or months until the local water committee can afford to fix it. At times, the municipal government (not SIMAPAG) intervenes and partially or fully pays for the fixing of equipment, or if necessary purchases new equipment (SIMAPAG., personal communications, April 2016).

Water-truck from SIMAPAG

Source: (www.simapag.gob.mx)

4.2 A View of Seven Communities: Cases in Oaxaca and Guanajuato

To illustrate how water provision in rural communities works in practice, this thesis examined the case of seven rural communities as indicated in section 3.3.1., each section introduces each case (rural community) with its characteristics and findings from data collection methods according to the proposed framework as indicated in section 3.2.

4.2.1 Rural Community in Oaxaca: San Antonio del Barrio

San Antonio del Barrio (SAB) is a rural village with approximately 200 inhabitants (interview with locals) part of the Municipality of San Felipe Usila (pop. 11,500) located in the northern part of the State of Oaxaca. It is a highly mountainous area located in the Papaloapan Basin which makes it a hard to reach community by road (INAFED, 2015).

Inhabitants from SAB are mostly indigenous "Chinantecos", most of them being bilingual. San Antonio del Barrio has its own form of government and organization; this community is part of the ones known as "Usos y Costumbres" which means that they can govern themselves.

An important note is that inhabitants were skeptical about any research due to bad experiences from the past (Survey Data at SAB, personal communication, March 2016).

F*igure 4-1 Local inhabitants with the author (center).*

Source: (Photo by Maria P., March 2016)

Article 2 of the Mexican Constitution, guarantees that indigenous communities have their own right to govern themselves according to their customs and traditions. Therefore, in the case of SAB, they have a general assembly where all men in the community older than 16 and younger than 65 must participate to conform it. This assembly acts as the maximum authority within the community.

The assembly appoints a main manager known as "Comisariado de Bienes Comunales" (public goods commissioner) who has executive functions. At the same time, the assembly appoints diverse commissioners along with duties. All service roles are honorary hence; they do not perceive any salary for their communal work (personal communication, March 2016).

Table 4-1 Characteristics of San Antonio del Barrio

Name of Rural Community	**San Antonio del Barrio**
Municipality	San Felipe Usila
Inhabitants (Survey)	200
Water Treatment on Site	Chlorination, boiling at households.
Local Water Committee	All matters are discussed in the General Assembly
Water Source	Water Springs
Marginalization Index	High
Water Quality	Seemed of Good Quality (Perevochtchikova, 2016)
Main Economic Activities	Agriculture for self-consumption, Forest Preservation

Sources: (INEGI 2010, SEDESOL 2010, interviews and field survey)

SAB recently got piped water in to every household; it was in 2015 when the Municipality along with the National Commission on the Development of Indigenous People (CDI) financed the project (Survey Data at SAB, personal communication, March 2016).

F*igure 4-2 Improved water infrastructure in SAB*

Source: (Photo taken by the author, March 2016)

At SAB, they take raw water from 3 different wells, where they transport it with pipelines and store it in water tanks where water is chlorinated. This process is done monthly by the Municipality (personal communication, March 2016).

During the visit, Maria Perevochtchikova, a hydrologist, mentioned that water obtained on site seemed of good quality.

The survey results demonstrated that majority of inhabitants boil their water at home on a regular basis, although a small percentage (15%) chlorinates water. Some locals alleged that they dislike the taste of chlorinated water, therefore they prefer to boil it. Majority of inhabitants are satisfied with the recent water works. However, they consider that further investment shall be made to improve sanitation conditions.

It is relevant to say that most of the inhabitants there collect and use firewood for cooking. The survey estimated that about 25 logs are needed every day for the average household. These people have to spend a lot of time to be able to cook and boil water (personal communication, March 2016).

After interviewing the nurse on site, the author can conclude that waterborne diseases are uncommon in the area, but still happen for unclear reasons, being the most common diarrhea in children. The nurse said that, inhabitants are aware of the importance of boiling water, which they mostly do, she argues that this is derived from educational campaigns promoted by social programs (personal communication, March 2016).

Table 4-2 Findings according to proposed framework in SAB

Condition	**Findings**
1. Community Engagement	The community is well engaged, even though women are enrolled in water related activities, they have no decision-making capacity.
2. Involvement of Government	Local, State and Federal government are involved in the system through investment, social programs and municipal government is involved in monthly control of Water System.
3. Sustainability in Decision-Making and Planning	Locals perform sustainable practices; they have a strategy in place regarding best sound practices.
4. Consolidation of Responsible Local Actors	Local actors are well consolidated; the General Assembly oversees all issues and appoints responsible agents.
5. Assessment of Social, Economic, Environmental and Technical Conditions	Federal agencies performed an assessment on social and economic conditions of each region.
6. Self-Financing	There are neither fees nor limits in water usage. The municipality maintains the chlorinator.
7. Regulatory Framework	Adequate regulatory framework in place based on customary law that allows for conflict resolution.
8. Acceptability and Suitability of Technical Solutions	Current technical solutions are not enough for water purification; people dislike the taste of chlorine, partial acceptance of solution.
9. Training and Education	Good training and educations from Federal Social Programs.
10. Effective Control and Follow Up	Municipality and Local NGO performs bi-monthly visits to control the Water System, health authorities perform weekly visits to address any issue.

4.2.2 Rural Communities in Guanajuato State

Guanajuato is a State located in the central part of Mexico, some of its cities have been exponentially growing and very dynamic. However, there are still thousands of its inhabitants that among other things lack drinking water. This situation concentrates in rural settings, even though major problems are also present in urban areas (CEAG, personal communication, April 2016).

For the case of Guanajuato, six communities in three different municipalities were selected as indicated previously in section 3.2.

Table 4-3 Characteristics of selected rural communities in Guanajuato

Name of Rural Community	**Picones**	**El Terrero**	**El Laurel**	**Terreros de la Concepción**	**"Los Pirules"**	**La Cinta**
Municipality	Guanajuato	Guanajuato	Guanajuato	San Luis de la Paz	San Luis de la Paz	Dolores Hidalgo
Inhabitants	60	260	81	190	170	100
Water Treatment	None	None	None	Individual Household Filters	Community Purification Plant	Shared Purification Portable Unit
Local Water Committee	None	In formation	Working	Working	Working	Working
Water Source	Water Springs	Water Springs	Water Springs	Underground Wells	Underground Wells	Underground Wells
Marginalization Index	High	Very High	High	High	High	Medium
Water Quality	Poor Quality	Poor Quality	Poor Quality	High in Fluorides and Arsenic	High in Fluorides and Arsenic	High in Fluorides and Arsenic
Main Economic Activities	Charcoal Making	Charcoal Making	Charcoal Making	Agriculture	Agriculture	Agriculture

Sources: (INEGI 2010, SEDESOL 2016, SIMAPAG 2016, CEAG 2016, and field survey)

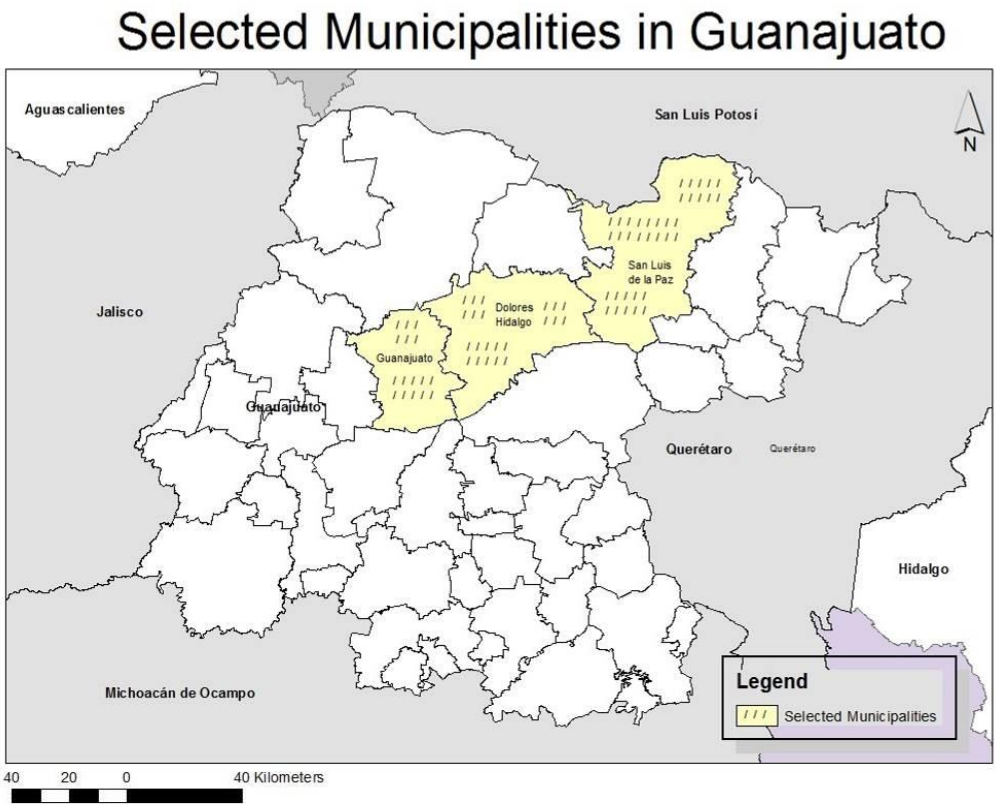


Figure 4-3 Location of selected municipalities in Guanajuato State

Source: (Created by the author, May 2016)

4.2.2.1 Communities in Guanajuato Municipality

Picones, El Terrero, and El Laurel, are located in the Municipality of Guanajuato. The main economic activity and source of income is charcoal making.

4.2.2.1.1 Picones

Picones is a small community with about 60 people. Local inhabitants get water from different water springs, but mainly one (personal communication, April 2016). During the site visit to the main water spring, the water there seemed green and contaminated with organic waste (leaves, mud). Local inhabitants have an improvised water hose that serves to transport water to a common water tank close to their homes being approximately 700 meters away. Locals do not pay anything for the water they take from the water springs (personal communication, April 2016).

Figure 4-4 Contaminated water spring in Picones with local inhabitant

Source: (Photo taken by author: April 2016)

Community members try to get water from better sources, however, water is scarce and they have to walk for several kilometers to obtain better water from another spring and stream. Picones does not have a local water committee in place. However, locals along with SIMAPAG are working to set one in place. The

survey demonstrated that water borne diseases are common especially in children, as most inhabitants do not treat water at all (personal communication, April 2016).

Table 4-4 Findings according to proposed framework in Picones

Condition	Findings
1. Community Engagement	The community is relatively involved; the local delegate is the main person in charge of decision making on site. Community members participate when they are asked to do it.
2. Involvement of Government	Low level of involvement from Government Agencies, just a slight presence of local Water Agency (SIMAPAG).
3. Sustainability in Decision-Making and Planning	No indication of sustainability in decision making, a water project was developed my SIMAPAG to provide clean water.
4. Consolidation of Responsible Local Actors	The delegate is the main responsible; they are working on establishing a local water committee.
5. Assessment of Social, Economic, Environmental and Technical Conditions	Federal agencies performed an assessment on social and economic conditions of the region.
6. Self-Financing	There are no fees in water usage from springs.
7. Regulatory Framework	No Regulatory Framework in place.
8. Acceptability and Suitability of Technical Solutions	The are no technical solutions in place that ensure drinking quality.
9. Training and Education	No training, lack of education in hygiene and water importance practices.
10. Effective Control and Follow Up	No control or follow up on site.

4.2.2.1.2 El Terrero

El Terrero is one of the poorest communities in the municipality of Guanajuato (SEDESOL, 2016). Locals get their water from two water springs located about 1.5 km and the other 3km away from households. Currently, they have to walk to obtain water, as current infrastructure (water hoses) is not working. Conflict related to water provision was detected among community members. Most inhabitants are desperate to find a solution to their current water problem (personal communication, April 2016). During the site visit, the author tried to interview the staff from the local health care center, however it was closed at the time, locals

mentioned that it does not open frequently. Open defecation practices are common in the area (personal communication, April 2016).

Figure 4-5 Improvised water solution on spring at El Terrero

Source: (Photo taken by author: April 2016)

The survey (April 2016) indicated that locals do not pay any money for the water they take from water springs. In El Terrero, a series of water containers (10,000 L) were observed, however they are not used due to the lack of water infrastructure. Most locals walk at least twice a day with water containers to obtain their water. At the local store, one can buy bottled water and other drinks including beer and soft drinks (personal communication, April 2016).

Most people consider that they would accept any water purification technology; however, they would find it difficult to pay for the treated water (personal communication, April 2016).

Table 4-5 Findings according to proposed framework in El Terrero

Condition	**Findings**
1. Community Engagement	Community members are engaged (mainly men), however, some conflict was detected among members.
2. Involvement of Government	Low level of involvement from government agencies, just the local Water Agency.
3. Sustainability in Decision-Making and Planning	No indication of sustainability in decision making, a water project was developed my SIMAPAG to provide water.
4. Consolidation of Responsible Local Actors	No responsible body in place. They are working on establishing a local water committee.
5. Assessment of Social, Economic, Environmental and Technical Conditions	Federal agencies performed an assessment on social and economic conditions of the region.
6. Self-Financing	Locals do not pay for water; however, they pay for electricity.
7. Regulatory Framework	No regulatory framework in place.
8. Acceptability and Suitability of Technical Solutions	There are no technical solutions in place that ensure clean water. Current infrastructure is damaged.
9. Training and Education	No training, lack of education in hygiene practices and water´s importance.
10. Effective Control and Follow Up	No control or follow up on site.

4.2.2.1.3 El Laurel

El Laurel is very hard to reach by road, as the road is devious and in bad condition. Inhabitants get their water from a spring located about 300 meters from their households. Social conflict was detected as locals mentioned that the Delegate takes all the benefits of social programs for her and her family. For instance, a donation given by the Rotary Club several years ago, a water tank that supposed to be for the use of all, it is in her property and according to locals, she does not allow other to use it (personal communication, April 2016).

Open defecation practices are common in the area, locals mentioned that every other week a health brigade comes, the health center officials were not reachable.

Inhabitants mentioned that they are desperate to get a water provision system in place, as they have to walk several times a day to get water from the spring. They would improve their water conditions if they could afford it (personal communication, April 2016).

The survey pointed out that, educational talks have been taking place, relating to hygiene. Most of inhabitants boil or chlorinate water and some use artisanal filters to remove large particles. Most locals pointed out that they would pay for clean water, and this fee should be decided according to their financial conditions (personal communication, April 2016).

Figure 4-6 Close-up to Spring in El Laurel

Source: (Photo taken by the author, April 2016)

Table 4-6 Findings according to proposed framework in El Laurel

Condition	**Findings**
1. Community Engagement	Community members are engaged mainly being women, however, some conflict related to water provision was detected among them.
2. Involvement of Government	Low level of involvement from Government Agencies, just the local Water Agency.
3. Sustainability in Decision-Making and Planning	No indication of sustainability in decision-making, a water project was developed my SIMAPAG to provide piped water.
4. Consolidation of Responsible Local Actors	There is a Water Committee in place, it is working well, however, there is conflict between the Water Committee and the Delegate.

5. Assessment of Social, Economic, Environmental and Technical Conditions	Federal agencies performed an assessment on social and economic conditions of the region. SIMAPAG developed a technical assessment for water provision.
6. Self-Financing	There are no fees in water usage from the spring. Locals would not want to pay for water service.
7. Regulatory Framework	No regulatory framework detected.
8. Acceptability and Suitability of Technical Solutions	The are no technical solutions in place that ensure clean water.
9. Training and Education	There has been training regarding hygiene and water management.
10. Effective Control and Follow Up	No control or follow up on site.

4.2.2.2 Communities in San Luis de la Paz and Dolores Hidalgo

During the research, after interviewing staff from CEAG, the author had a chance to visit three other communities where water purification solutions have been recently installed. These solutions were provided with funds from PROSSAPYS, and in one case (La Cinta) with funding from a local NGO (personal communication, April 2016).

These cases are different from the previous ones as in these communities they get water from underground water wells from ranges varying from 450m to 700m.

According to an interview with experts from CEAG, the water in these three communities presents unsafe levels of toxic arsenic and fluorides, being that reason the main driver for the installation of such purification units. (CEAG, personal communication, April 2016)

At the time, these technologies were being tested to determine if they meet the technical requirements. During the site visit, as seen on the photo, a portable lab was carried by CEAG, to perform tests on water quality.

Figure 4-7 CEAG's Personnel taking water samples

Source: (Photo taken by the author, April 2016)

4.2.2.2.1 Terreros de la Concepción

Terreros de la Concepción is located in the municipality of "San Luis de la Paz". There are about 147 inhabitants. A water-purification community-plant has been installed on site since 2015. The funding was from PROSSAPYS through CEAG. (CEAG, personal communication, April 2016)

According to findings from interviews, inhabitants seemed satisfied with the plant, however, they were concerned as they said that from time to time they cannot afford water fees. As this community has a Reverse Osmosis technology in place, inhabitants seemed worried about the water discharged by the purification plant.

Some conflict was detected among members, however interviews proved that community members are eager to participate and contribute as much as they can for a good water service. Local conditions are analyzed in the next table:

Table 4-7 Findings according to proposed framework in Terreros de la Concepción

Condition	**Findings**
1. Community Engagement	Good participation from local members, a water committee is working well and have high participation rates.
2. Involvement of Government	Moderate level of involvement from Government Agencies (State and Municipal Level):
3. Sustainability in Decision-Making and Planning	No indication of sustainability in decision making.
4. Consolidation of Responsible Local Actors	The water committee has been working for several years, they meet regularly and have different responsibilities.
5. Assessment of Social, Economic, Environmental and Technical Conditions	There has been assessment of such conditions done by CEAG before the installation of the Community Purification Plant.
6. Self-Financing	They pay for the water they use, a monthly fee, however for drinking water they have two options, one is to go to the community level plant where they buy 19l water containers for 6 ($ MXN) being about (0.35 USD). CEAG is testing new filter for each household, they would pay for initial investment and user will pay for replacement parts.
7. Regulatory Framework	There exists a local regulatory framework.
8. Acceptability and Suitability of Technical Solutions	Water for domestic use is chlorinated. Water for drinking goes through an Inverse Osmosis process in the Community Purification Plant. This plant is owned and operated by the community. Users dislike the discharge water from the Inverse Osmosis plant.
9. Training and Education	Locals are aware of clean water importance and have a paying culture mindset.
10. Effective Control and Follow Up	There is some control from municipal water agency and CEAG.

4.2.2.2.2 Los Pirules

Los Pirules is located in the municipality of "San Luis de la Paz". There are about 170 inhabitants. A water purification community plant has been installed on site since 2015, similar to the plant in Terreros de la Concepción. (CEAG, personal communication, April 2016)

Figure 4-8 Community water purification plant at "Los Pirules"

Source: (Photo taken by the author, April 2016)

According to findings from interviews, Inhabitants seemed satisfied with the plant. Due to the limited availability of locals, findings were limited. The next table presents the local conditions:

Table 4-8 Findings according to framework conditions in Los Pirules

Condition	**Findings**
1. Community Engagement	No information
2. Involvement of Government	Moderate level of involvement from Government CEAG and Municipal Agency.
3. Sustainability in Decision-Making and Planning	No information.
4. Consolidation of Responsible Local Actors	The water committee is working well; the community purification plant reports good management of the plant.
5. Assessment of Social, Economic, Environmental and Technical Conditions	There has been assessment of such conditions done by CEAG before the installation of the Community Purification Plant.
6. Self-Financing	They pay for the water they use, a monthly fee, however for drinking water they have the option to go to the community plant where they buy 19l water containers for 6 ($10 MXN) being about (0.45 USD).
7. Regulatory Framework	No information
8. Acceptability and Suitability of Technical Solutions	Water for domestic use is chlorinated. Water for drinking goes through an Inverse Osmosis process in the community Purification Plant. This plant is owned and operated by the community.
9. Training and Education	No information
10. Effective Control and Follow Up	There is some control from CEAG.

4.2.2.2.3 La Cinta

La Cinta is a community located in Dolores Hidalgo, there are about 100 inhabitants, during this visit to a household, 5 water users and 2 members of the water committee were interviewed. They got a portable shared water purification unit, donated by a local NGO (CENTAM).

Figure 4-9 Shared reverse osmosis filter being used at La Cinta

Source: (Photo taken by the author April 2016)

This NGO provides monthly follow up and users seemed satisfied with unit, however some conflict related to the paradox of common pool resources are present, users have been able to solve this out with help of CENTAM. For clarity purposes, more findings are presented in the next chart.

Table 4-9 Findings according to framework conditions in La Cinta

Condition	**Findings**
1. Community Engagement	The community is well involved. The work of a local NGO has facilitated this. The NGO donated several water purification systems in the region that about 5 families shared.
2. Involvement of Government	Scarce level of involvement from Water Agencies, just CEAG to monitor drinking quality.
3. Sustainability in Decision-Making and Planning	No information.
4. Consolidation of Responsible Local Actors	Each series of households have well consolidated water committees for water purification, for the provision of water, there is a local water committee in charge of taking care of it.

5. Assessment of Social, Economic, Environmental and Technical Conditions	No information
6. Self-Financing	People pay a water fee for water for domestic use and pay for the replacement parts of the filters.
7. Regulatory Framework	A regulatory framework is in place that allows for conflict resolution.
8. Acceptability and Suitability of Technical Solutions	There are shared Inverse Osmosis Filters that guarantee that water treated is safe for drinking purposes. Conflict was detected among users of shared filter, due to overuse or mishandling of unit.
9. Training and Education	Some training sessions have been performed by NGO, locals seemed aware of drinking purified water and most are eager to pay for replacement parts.
10. Effective Control and Follow Up	Control by NGO performed bi-monthly.

4.3 Focus Group on the Feasibility of Implementing PAUL as a Solution

In this part of the research two focus groups took place with experts from SIMAPAG and CEAG and locals as seen on Table 4-10. These were concerning the feasibility of PAUL, as an example of a water purification solution in the selected rural communities.

Table 4-10 Assistants to focus groups

Name of Participant	**Position**
Aáron Zamora	Head of Planning of SIMAPAG
Maria Rangel	Rural Communities Attention at SIMAPAG
Mónica Chowell	Purification Technologies at CEAG
Joel Alférez	Agency Strengthening Department at CEAG
Locals from El Laurel	They preferred to be kept anonymous
Juan Andrés García Padrón	(Author) Moderator

Experts from CEAG agreed that PAUL could be a good example of a solution to try out, in order to tackle the water contamination problem of rural villages, especially in those using surface water as main source (personal communication, April 2016).

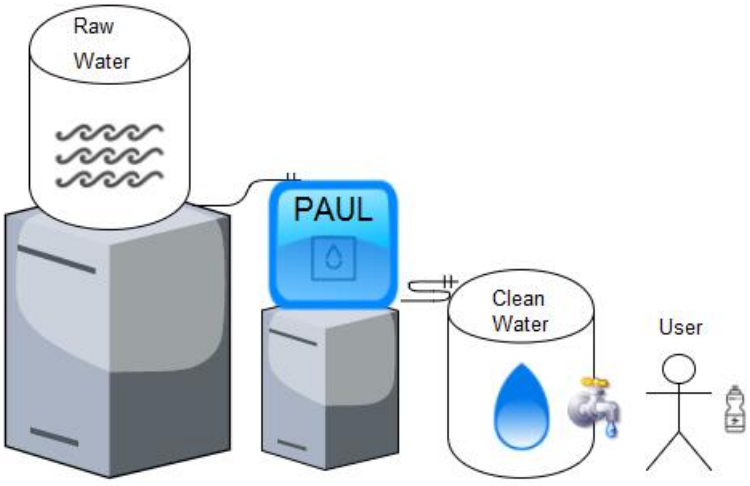
People from SIMAPAG seemed very surprised and interested on the technology behind and ease of use of PAUL. They share some of their knowledge on water purification devices and testify that according to their experience, this type of devices could work with the help of a well-established framework for its operation (personal communication, April 2016).

Figure 4-10 Research activity

Source: Photo taken by the author (April 2016)

Aaron Zamora recommended to talk to the potential users, before hand to inform them about the advantages and operation of PAUL. One problem he noticed, was that water treated with PAUL should be used only for human consumption, as there are many water uses in rural communities, such as agriculture, raising animals or cleaning.

The main findings from this research approach are that PAUL would be a valuable unit wherever it is chosen to be implemented. Community engagement will be very relevant in order to take care of the PAUL.



Relating the technical conditions, simple drawings were made to determine how would it be best place and in which community was most needed. Terreros, as having the most need for clean water based on the number of people proved to be a good community for its implementation.

One of the challenges is that the membrane needs to be changed every 10 years, thus an issue would be to have access to the replacement part and an effective follow-up through time.

5 Analysis and Discussion

After presenting the findings. Firstly, this chapter analyzes the implications of findings from the data collected during the research course of this investigation. Secondly, a discussion takes place arguing on the robustness of framework utilized and the validity of the methods and findings.

5.1 The Complex System for Clean Water Provision

In the author´s perspective, in most of the studied cases it was until the government's intervention (through the local water agencies), that the community got improved water service, therefore the author considers this as crucial in all stages of CWPS.

Considering that, one of the most common arguments given by authorities was the lack of financial capacity. During the research course, the author encountered some cases of senseless prioritization of needs. For instance in a case of SIMAPAG, according to public data found on local media, SIMAPAG prefers to spend exorbitant amounts of money on unimportant things such as advertising (to inform on its yearly activities), instead of investing in water provision (Refer to http://www.am.com.mx/2016/05/16/guanajuato/local/derrochan-recurso-en-informe-284449). It is widely known that in Mexico, the use of public funds for the promotion of individuals with political aims is a common practice.

Another related aspect found is the lack or inadequate planning from local water agencies, for example, they pay for superfluous technical solutions or unneeded equipment when there are similar technologies or alternatives that can provide the same level of service for lower prices. An example found is that SIMAPAG uses large-sized pick-up trucks (low-fuel efficiency) for mostly all their tasks, that in many of the cases could well be perform using smaller and more-efficient-fuel cars or making use of alternative transport systems such as bicycles.

A common feature found at higher levels of management, it is that positions are not being assigned based on educational or professional experience, instead, many positions are filled using nepotistic and political reasons. This can lead to a vicious cycle due to the lack of professionalization and commitment within the Instititution.

Concerning communities, as we have seen in the previous chapter, communities are different, each one has its own problems, concerns, and solutions; however, they share similar structures in managing their affairs and methods of getting water.

For rural communities where government involvement was inexistent, most of the time locals hoped for the government to come and solved their water problem, as they argue that they did not have any other choice. One must think that due to poverty conditions locals do not have the means to get improved water services in place for themselves.

In some of the studied communities, social conflict among members deters community engagement. For example, conflict can arise from issues such as who in the community has the right to obtain water from a certain spring, or to the issues of where the water infrastructure (such as water pipelines or filters) is being placed. A solution found to mediate such conflict is the prudent intervention from government officials as it proved to be effective in terms of solving previous cases. In the case of SIMAPAG, a specialized unit in set in place to take care of rural communities and address this kind of situations if they arise.

The author found that some of the administrative process relating to the provision of clean water, seemed inefficient. Simpler processes can ease the administrative burden as well as an effective coordination among water agencies.

Pilot-projects were highly recommended in order to test technical solutions on site, the findings demonstrated that promising technical solutions were incapable of meeting up with the challenge or the lack of preparation or planning compromised the development of water agencies.

5.1.1 Analysis of the Water Provision System

The whole process behind providing water in to rural communities in Mexico can be quite complex, because it involves many relations among various actors such as: governmental agencies, international agencies, NGOs, private sector, academia, water users, and others. This does not mean that they are or should be present at all times in the CWPS.

For example, in the case of "Terreros de la Concepción", they get water from a contaminated well (arsenic and fluorides). For that reason, the money used to install the Community Purification Plant came from PROSSAPYS. CEAG implemented and planned the project by contracting a private solicitor, and water users formed a local committee to operate and maintain the system. If you go further in details, spare parts for the purification plant come from third party individuals, and bottled water companies are present in the community.

Considering the above, each case is different; consequently, the process of water provision in to rural communities in Mexico can differ a lot in its process, its financing and operation.

For that reason, the author developed a chart (Figure 5-1), that portrays all identified Actors (agents) involved in the process of providing clean water to a rural community in Mexico, along with their interaction and activity. Acknowledging that, this chart is merely for illustrative and descriptive purposes, taking in to consideration the complexity of the system.

As one can see in the following chart, actors (agents) are interconnected at different levels and processes.

- Government Agencies interact according to their responsibilities and capacities as explained in Chapter 2.
- The private sector can get involved in the construction water purification works or by selling bottled water.
- In some cases, NGOs can play an important role by donating infrastructure and equipment or by training locals on how to operate technological solutions.
- Research institutions or technology developers can contribute by designing solutions or research for policymakers or produce innovations such as PAUL.

In the next page, the mentioned chart is presented, please refer to section 2.1 of this thesis for more info on the institutional framework and policy.

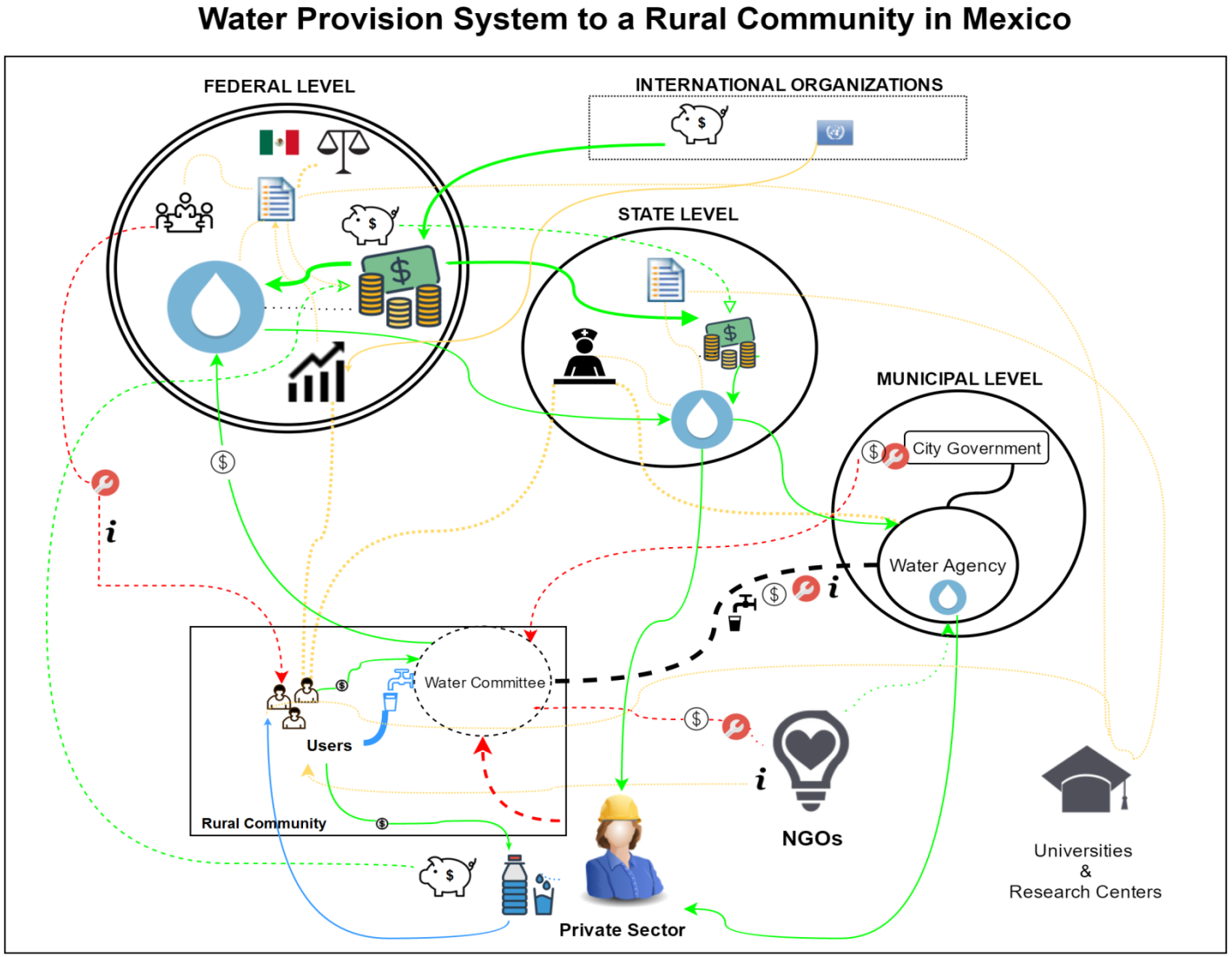


Figure 5-1 Water provision system to a rural community in Mexico

Arrows and lines indicate interaction, connection and processes.

The width of lines symbolizes strength and importance of the interaction.

Black represents the main responsible of ensuring water in rural communities.

Blue represents water provision.

Green represents cash flow in terms of payments, subsidies or loans.

Red can represent infrastructure, technical or financial assistance.

Yellow represents information and data flow (trainings, stats, research).

(Created by the Author, 2016)

NO TEXT

5.2 Mirroring the Selected Framework Against the Research Findings

In the following section you will find a critical analysis of current conditions of water provision in the studied communities. In Chapter 3, the author selected key conditions for the success of a CWPS, based on the concepts reviewed in the literature review.

In order to analyze the results from each community, one must put a value or take a comparative scale, but at the same time one must keep in mind that things should be kept simple and explanatory. For this case, for the analysis of these conditions the author chose to use a "Traffic Light Approach" for quality evaluation, based on current conditions according to the data gathered.

The Traffic Light Approach for quality evaluation can be a good and simple way to analyze qualitative data. It can also be good method to spot success, risks or failure, and may also help stakeholders to set priorities, and compare cases.

In order to preserve consistency and validity of the data, the author followed a consistent and unbiased approach while analyzing the obtained data. The classification used is based on the four following categories of the status of current conditions. The next four colors represent such categories as follows:

- Green indicates that current conditions are optimal and no immediate attention is required.
- Yellow indicates that conditions are partially met; attention for improvement is required.
- Red means that this condition is not present at all, urgent attention and action is required.
- White means that there was insufficient information to determine the status of this condition. Making it an opportunity for future research.

The author acknowledges that this method might not represent a full analysis of the current conditions of the water system in such communities, however this analysis can be a good baseline for analysis.

Another limitation can be that the data obtained during research was the most readily available, and might not have taken in to consideration a full representation on the perspectives from all stakeholders. However, the author considers that this analysis approach could be performed with the obtained data getting reliable results.

In the following page, one can see the results of this analysis on Table 5-1.

Table 5-1 Analysis of communities using Traffic Light Approach

Community / **Condition**	**San Antonio del Barrio**	**Picones**	**El Terrero**	**El Laurel**	**Terreros de la Concepción**	**Los Pirules**	**La Cinta**
1. Community Engagement	Y	Y	Y	Y	G	W	G
2. Involvement of Government	G	Y	Y	Y	Y	Y	Y
3. Sustainability in Decision-Making and Planning	G	R	R	R	R	W	W
4. Consolidation of Responsible Local Actors	G	R	R	Y	G	G	G
5. Assessment of Social, Economic, Environmental and Technical Conditions	G	Y	Y	Y	G	G	W
6. Self-Financing	Y	R	Y	R	G	G	G
7. Regulatory Framework	G	R	R	R	G	W	G
8. Acceptability and Suitability of Technical Solutions	Y	R	R	R	Y	G	Y
9. Training and Education	G	R	R	G	G	W	G
10. Effective Control and Follow Up	G	R	R	R	Y	Y	G

As one can see, the most greens are in San Antonio del Barrio. Then La Cinta and Terreros de la Concepción follow with six each one. Los Pirules got 4. Some conditions were yellow and therefore require some improvement. The worsts conditions were observed in Picones, El Terrero and El Laurel, as they got 7, 6 and 5 conditions in red, therefore, urgent attention is required in those in to guarantee the human right to access to water.

5.3 Discussion

5.3.1 Robustness of Framework

In this section a discussion on the robustness of the framework takes place. During the literature review diverse concepts were presented regarding clean water provision systems (CWPS) in rural communities.

Following that, the author developed a framework of conditions with key elements from the revised literature, considering which conditions would be needed to support sustained CWPS in to rural communities in the Mexican context.

The revision of literature proved that these conditions are relevant for any water provision system. The strength of the CWPS depends on the strength of its condition. It is clear that the ultimate goal for any water provision system is to provide sufficient clean water at the best cost and technical capacity.

The author clearly understands that these conditions are different and therefore, they have different importance and cruciality for a CWPS to serve its main purpose of delivering clean water to users, for that reason an endless discussion could embark on which condition is more important than other.

This will depend on a number of factors, that are related to the way the CWPS is organized, functioning as described in Section 5.1. Consequently, in order to address the issue of importance and cruciality of conditions the author develop the following chart that portrays the aforementioned.

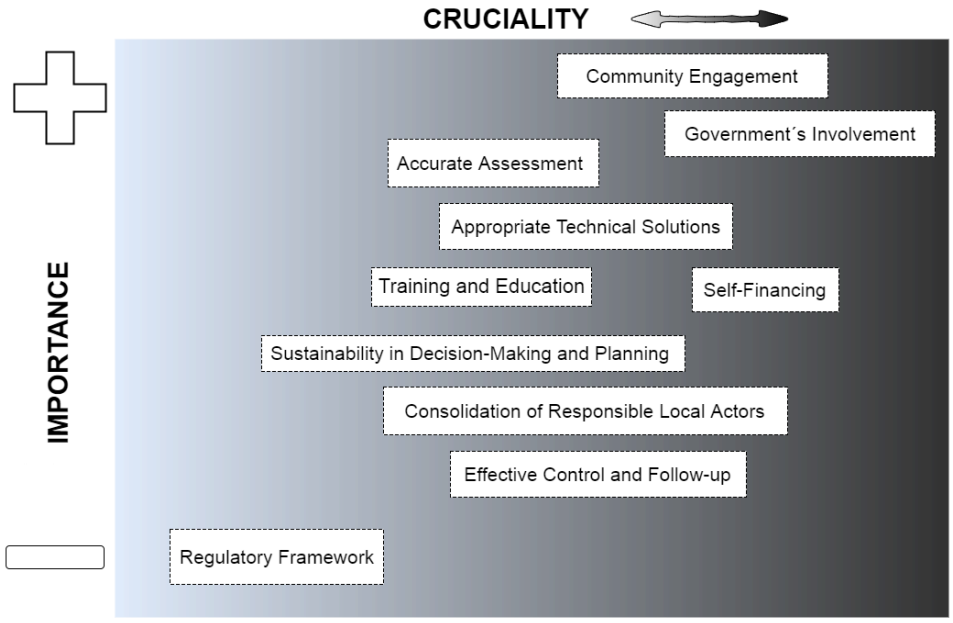


Figure 5-2 Importance and Cruciality of Conditions

Source: (Created by the author, May 2016)

After the research period the author believes, as seen on the previous chart, that 6 are the most important and crucial conditions. These refer to the involvement of government in all its aspects, community engagement for self-governance and contribution to the CWPS, accurate

assessment of the context in order to develop appropriate technical solutions, and another aspect, that is strongly-related to community engagement, is self-financing of the system, thus, the system can sustained itself, and finally training and education in order for users to be aware of the importance of clean water and responsible agents to be trained on how to handle and maintain and manage the CWPS.

The author believes that this framework serves as a good baseline to analyze and strength CWPS. One must consider that systems and institutions are constantly changing. Work is needed from all stakeholders to maintain a solid CWPS, or make efforts in order to improve conditions if it is needed.

It is clear that this framework is not covering all aspects from a CWPS, as the topic is very complex. Each case is different and conditions might need to be adjusted depending on local context and features, however, this framework could be used in similar cases.

It is certain that it would be ideal to have more research and discussion that determines if the framework covers all ideal aspects for a CWPS, nevertheless, after this work´s thesis, the author believes that this framework serves as a good baseline to analyze and ensure conditions for a sustained, well-managed, controlled and effective CWPS.

The author believes that the framework could be used if adapted right for other cases such as in urban areas, or for other basic services such as sanitation provision. The main intention of creating this framework was not for creating itself, as the concepts have been proven in many research studies as covered in the literature review, rather its main attention was to develop a framework for analysis to research these particular case studies while thinking on replicability.

5.3.2 Pertaining Methods

Since the beginning this thesis aimed at findings ways to improve water conditions of rural communities, and the research embarked in the search for relevant knowledge. That being clear, one disadvantage from the research's findings was that information gathered was obtained rapidly and without a follow-up method. This rapid approach limited findings with the confidence that many social scientists expect from such type of social research.

Multiple methods allowed the author to cross-check findings, increasing confidence of the data that allows to say that the author clearly understood the essential features of the existing water situation in the selected communities.

The interviews and site observations were the methods that proved to be most helpful. The semi-structured settings of interviews allowed for good flowing of information and the author allowed himself to go further than the original planned questions, this proved to be very helpful in order to understand the whole picture.

The surveys proved to be a good method to gathered simple data in order to make reasonable generalizations on the water conditions of each community. However, many locals were not interested in participating, which made it a difficult task.

For the focus groups, the ideas from practitioners enriched the perspective of the author in order to propose an example of installation of a water technology such as PAUL. The author, got to know more information and perspectives from previous experiences which enriched this material. However, it is clear that is impossible to portray all learnings from such activities on this paper.

In terms of the visualization portrayed in Section 5.1, displaying the complex system of water provision in Mexico in to a rural community. The author believes that this was the simplest and finest way of portraying all learning gathered during this research process, in order to show the level of complexity and detail for the reader. The author acknowledges that this chart might not include the infinite possibilities of all CWPS in Mexico, but at least tries to portray the identified connections, responsibilities and actors in a CWPS. At the same time, one must acknowledge that all connections are not always present and it greatly differs from case to case.

Concerning the analysis from conditions on selected communities performed with the traffic light approach, conditions in yellow and red should be addressed as soon as possible, or disruptions in the CWPS may occur.

Regarding the "traffic light approach" used for quality analysis and comparative purposes, this method proved to be helpful to better visualize the findings in the framework in Section 5.2, and enable to compare the case studies, at the same time the author understands that this approach can be limited, yet it provides an acceptable way for quality analysis.

Many factors might be involved, depending on the relevance of data gathered or conditions may change rapidly, therefore, one must consider such elements when reviewing such framework. Nevertheless, this method proved to be a helpful approach to better visualize and compare conditions in each community, while acknowledging its already cited limitations.

Photographs proved to be a fun activity during research, as it enabled the author to capture essential moments from the research course and to portray local conditions. The author encourages making use of photography to enhance visualization of thesis.

One of the most impressive findings from this thesis was seeing the governance system in action in San Antonio del Barrio, especially in their system in place for direct democracy, and to the community engagement to participate in common issues. These were remarkable and noteworthy to replicate in similar communities. This is partially in thanks of the hard of work of local NGOs and government involvement mainly related to the payment for environmental services.

In terms of the public programs for providing water, they should continue to be simplified in order to speed up processes, reduce costs and increase investment in water projects. The financial help of international organizations is a decisive support as seen for the case of PROSSAPYS. In the next section the conclusions and recommendations are presented.

6 Conclusions and Recommendations

This concluding chapter presents main findings and conclusions, in the second part of the chapter some recommendations are being provided including the further implementation of PAUL.

6.1 Conclusions

In Mexico everyone is entitled to the right of access to water for personal and domestic consumption, in a sufficient, safe, acceptable, and affordable manner, as it mandates the Mexican Constitution.

Each level (order) of government is involved at different levels and responsibilities in the water provision process. The main responsible authorities for ensuring clean water provision are municipalities, within their corresponding jurisdictions.

Cooperation and concurrency among water agencies has proven to be a key element in successful water project's planning, implementation and operation. Clean water provision goes beyond the installation of equipment.

It is clear that progress on water provision has been substantial over the last two decades, as indicated by the results presented in Chapter 1. However, the main challenges lie now in filling the full demand, and ensuring good water quality. Yet many local water agencies still lack the technical and financial capacity, and sometimes willingness to act in order to fulfil this basic need. Simpler solutions or methods, or to look for ideal solutions, are necessary.

Water provision can be a complex process in terms of, its prioritization on public agendas, number of actors, bureaucratic procedures, and local conditions.

A list of 10 conditions for sustaining CWPS were selected from the revised literature in order to have a framework for analysis of the current situation of the case studies.

Firstly, **Community Engagement,** and it means that the community is sufficiently engaged in the CWPS, there are "mechanisms" in place for equity in participation and contribution of all actors. For this condition, in the case studies, local water committees play a crucial role for ensuring and enhancing local participation.

Then, **Government's Involvement** in all phases of the CWPS. And that there is a sufficient liaison between the local water committees and the local government. Municipal water agencies should mainly intervene in controlling and monitoring of water quality and operation, and must get involved in order to enhance financial and technical capacities of local water committees and reduce the water affordability burden if needed.

Sustainability in Decision-Making and Planning along the phases of the CWPS. In order to tackle the clean water provision problem, an integrated approach and solution should be taken in to consideration.

Consolidation of Responsible Local Actors, thus a CWPS that includes responsible locals in the management, operation and control of the whole process.

An **Accurate Assessment** of Social, Economic and Environmental aspects as well as technical conditions were considered in all phases of the CWPS. This is important as rural communities

can have similar settings but each has unique characteristics, policy implementation should always look at each context and address its needs accordingly.

Mechanisms for **Self-Financing** are important to ensure continuous operation and increase resilience of CWPS. An important aspect to consider that water should not be treated as a commercial good, water agencies should keep this in mind in order to guarantee the human right of access to water for domestic purposes. At the same time, all stakeholders should fairly contribute to the maintenance and operation of the system (paying their water fees), and contributing to the good management and use of the systems. Subsidies from the government should be considered when needed.

A **Regulatory Framework** is needed for ensuring the operation of the CWPS, conflict resolution and allocation responsibilities.

Appropriate **Technical Conditions** ensure sufficient and clean water and (most) users accept and use them. Important to mention that water purification solutions should be, durable, resistant, low maintenance, economically viable, no requirement of spare-parts (for a long time), low-energy intensive or should not consume any electricity at all.

A phase of **Training and Education** to locals is important about the management, operation and maintenance of CWPS, importance of hygiene practices, and considering that many users do not want to pay for water service, importance of payment culture should be comprised in the teachings.

An **Effective Control and Follow-up** by responsible agencies or stakeholders is an important stage to monitor and ensure good conditions and long-term operation of CWPS. Transparency, control, and correctness in the use of funding is highly suggested.

Regarding findings from relevant stakeholders, they confirmed the relevance of the topic, pilot projects were recommended in order to first tests solutions before considerable implementation accompaniment and follow-up is a crucial phase in the development of any CWPS, concrete goals and a demand-based approach help as good drivers to increase the rates of water provision.

Concerning the findings from the communities selected as case studies, these communities proved to have different conditions in place in order to obtain clean water. In some of them, conflict among members, lack of government's involvement, poverty conditions, and the lack of financial and technical capacities, proved to be the main defies against CWPS. While in others, such as the case of San Antonio del Barrio, appraising levels of cooperation and collective action greatly supported CWPS.

The content and lessons gathered during research greatly helped in order to recommend in the following pages, guidelines for a practical example in the implementation of a water solution. PAUL proved to be a good solution for tackling the problem of clean water, especially in decentralized contexts and where water is obtained from surface sources.

6.2 Recommendations to the Targeted Audience

- To Public Administrators: Water provision goes beyond the installation of water infrastructure. Make use the framework to sustained clean water provision systems. Avoid bribery and ineffective and expensive purification solutions. Prioritize based on technical conditions not on political ones. Select trained and skilled personnel to serve

at all positions. Enhance communication and cooperation between agencies, learn from others and share your experience.

- To Researches: For technology developers of water solutions, keep your solutions simple, durable, low or no maintenance, electricity low or free, cost-effective and have different scales according to needs.
    - For PAUL's developers, consider re-sizing the device for different purposes such as household's level, encourage research to develop simple and cost-effective solutions that decontaminate water from toxic elements such as arsenic and fluorides.
- To other stakeholders: Specially to NGOs such as the Rotary Club, keep investing in water provision for rural communities, make special attention on sustaining the whole system (refer to the framework for sustaining clean water provision systems in section 3.2). Do follow-up and monitor the donated equipment, money and infrastructure. Contact me if you need help to improve water conditions in rural communities.

6.3 Example of Implementation: The case of PAUL

During the writing of this thesis, the author arranged for a donation of a PAUL with the commitment to put in place in one of the case study communities, depending on wherever it would be most needed and viable to operate according to the findings and learnings from this thesis.

Figure 6-1 PAUL: Portable Aqua Unit for Life Saving

Source: (Photo taken by Oliverio Garcia)

Nowadays, there are many ways of purifying water, new research and development has allowed for innovative techniques for providing safe drinking water. However many of these treatments are energy and chemically intensive and focused on large scale settings making it costly and technically challenging to operate (Shannon et al., 2008). That is the reason why, Professor Franz Frechen from Kassel University and his team of researchers developed the Portable Aqua Unit for Lifesaving, best known as PAUL, at the Department of Sanitary and Environmental Engineering at the Kassel University in Germany.

PAUL was first developed to provide safe drinking water on site to population affected by disasters. Later it proved to be a good alternative for permanent use, especially in decentralized settings, such as rural areas, schools, hospitals, etc., (Frechen, 2015b).

PAUL can deliver up to 6000 Liters of water per day (depending on circumstances) but typically delivers 1,200 liters of purified water. It doesn't require any electricity, chemicals, nor skilled personnel are needed for its simple operation. PAUL has been designed to be a very durable solution with a lifetime span of 10+years, and to operate in the roughest conditions, with minimum maintenance needed (backwash only). (Frechen, 2015b)

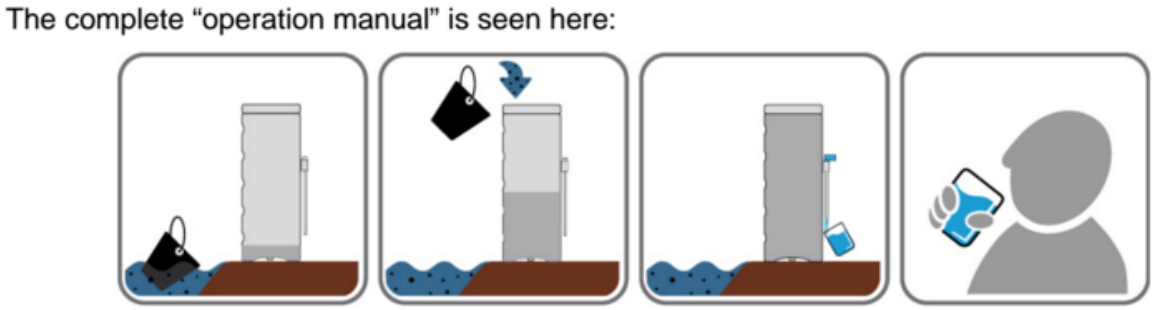


Figure 6-2 PAUL´s Operation Manual

Source: (Waterbackpack.org, 2016)

The technology used in PAUL consists on a pre-sieve and an Ultra-Low Pressure Ultrafiltration making used of an organic Polyether sulfone PES membrane. But the operation is quite simple as seen on Figure 6-2.

After a series of informal communications with his main developer, he indicated the positive experience and acceptance that PAUL has had wherever it has been deployed, making it a useful tool for aid organizations. Nowadays, more than 1500 PAULs have been deployed worldwide helping thousands of people(Frechen, 2015b). Reports gathered from implementation sites gathered by aid organizations document and demonstrate PAUL´s aforementioned benefits.

Comparative studies have shown that PAUL´s initial and operational costs are cheaper than similar options. (Frechen, 2015a) This method is cost effective mainly because it does not need any replacement spare parts in 10 years, making it a good independent solution.

6.3.1 Recommendations for PAUL's implementation

According the data gathered during the research of this project, and the concepts learnt from the literature review, PAUL should be place in a community that most needs the water and at the same time meets most conditions from the used framework to guarantee a successful operation.

If conditions are not present, work should firstly focus on creating such conditions understanding that not all of them should be there. Please refer to section 5.3.1 to consider the importance of these conditions.

After the findings from the focus groups, the author can conclude that PAUL could serve as a viable solution to address the lack of clean water in the selected communities (San Antonio del Barrio, El Terrero, Picones, El Laurel).

During the survey, the author explained the technology to the locals, consequently, they agreed that its operation seemed simple, and that they would be able to operate it.

In order to install PAUL, a local water committee should in place. This committee should be the one responsible for the care, operation and maintenance, of PAUL.

A water consumption fee should be established to ensure the operation and maintenance of the CWPS. This fee should be based on local economic and social conditions. The municipal water agency should be involved and subsidize the installation and operation process if needed, as well they should have a monitoring system in place that guarantees operation and controls the water quality.

The presence of soft drinks and alcohol spirits including beer was seen on all sites, as gathered from a focus group a frequent argument used by municipal agencies regarding water fees is that "if they can pay for a coke or a beer they might as well pay for cheaper drinking water".

The PAUL, should be placed in a public place (not the street), such as a school or health center, where users can easily reach it and where its safety its guaranteed. The place where the unit is deployed, should be as close to the geographic center as possible, for convenience purposes.

The PAUL should be owned at all times by the Municipal Water Agency, to avoid conflicts among members and possible theft.

A set of rules that outline responsibilities and rights from users should be develop by the local water committee with the help of municipal water agencies. The process for implementation PAUL can look or should consider the following steps based on the framework used in this thesis.

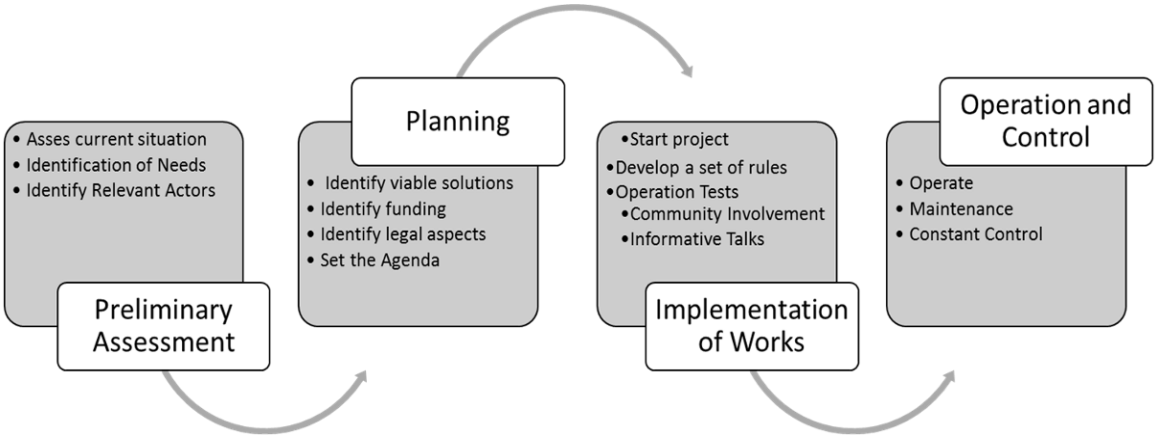


Figure 6-3 Recommended process for PAUL's implementation

In order to replicate the installation of such units, the investment cost of the equipment should be shared by municipal water agencies being the ones responsible for clean water provision.

6.3.2 Installation of PAUL

The proposed installation works best thus 19L containers can easily access clean water. Chlorination should be considered after treatment, or a sealed container should be used to prevent microorganisms to develop, for a visualization please refer to figure 6-4.

An informative talk and demonstration should be performed before its operation. In the following figure, a model for installation is suggested for long time operation of PAUL.

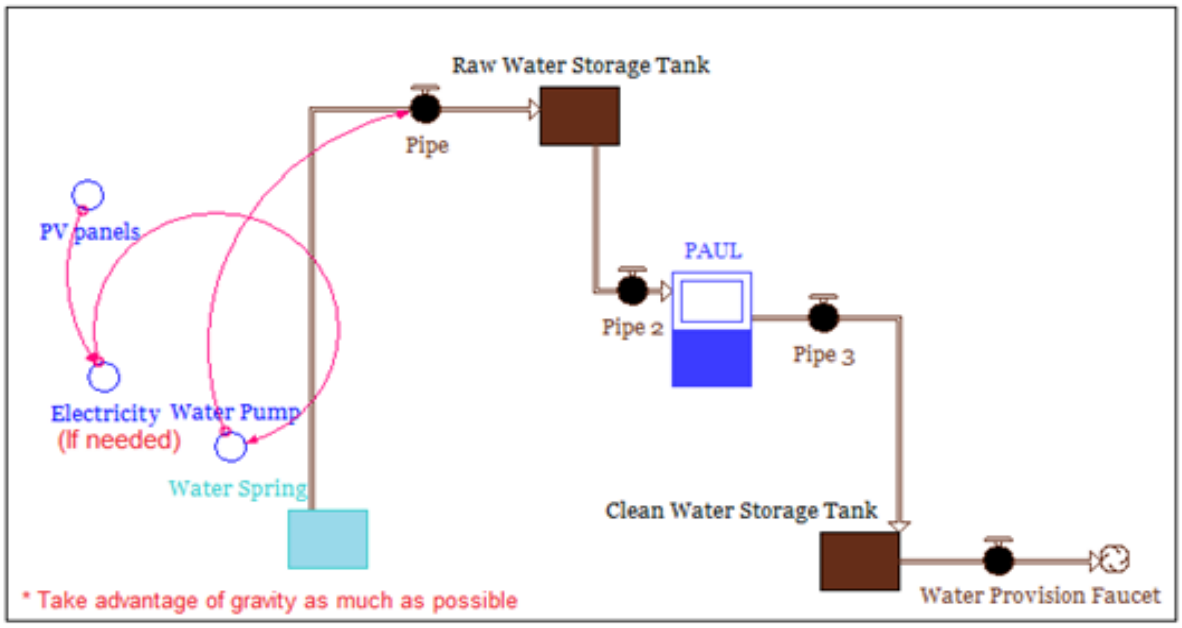


Figure 6-4 Recommended PAUL's Installation Model

6.3.3 Implications for Sustainable Development

Considering the aforementioned, the author can conclude that after the implementation of PAUL, there will be an improvement on the wellbeing of locals. As they will have to spend less time carrying water, they will not have to boil water, thus, reducing the amount of firewood or gas needed for cooking and the associated time and costs.

There will be an improvement in health conditions of inhabitants, as they will have access to clean water. Education process will be benefited as there will not be disruptions of classes due to health conditions and, or having to collect water or (less) wood, including also the educational talks about the importance of clean water and hygiene conditions.

Also, less emissions could come from less firewood being burnt and water trucks having to ride for hours to provide water, or transport bulky portable water purification plants to site. There are many more implications to reach sustainable development.

Another important aspect is the improvements on social relations by reducing conflict and encouraging community participation.

Table 6-1 Implications of Sustainable Development from PAUL implementation

Expected Benefits from PAUL's Implementation
Improvement of wellbeing
Improved health
Improved education process
Reduce emissions (from firewood burning) and water trucks
Enhancing the social fabric by reducing conflicts related to water

6.4 Suggestions for Further Research

This section discusses further research; it is clear that water provision is still a challenge to be solved in rural communities especially of the developing world. Considering the importance of the subject, new research is being developed every day. A lot of work is needed in the implementation and follow-up of projects depending on local circumstances. The author suggests to concentrate on practical approaches for providing water.

More research should be done on how to implement innovative solutions such as PAUL, for a successful implementation, taking in to consideration that each device's characteristics and needs are different. As well more research is needed that investigates pragmatic ways of improving the conditions in situ, as identified in Section 2.2.6.

Further research should address the issue of water contamination with arsenic and fluorides, especially in the State of Guanajuato, as local media reports that this contamination is posing a threat to the wellbeing of local inhabitants.

This thesis ends with the photograph taken by the author at "La Cinta", a community with high levels of arsenic and fluoride on water wells, he is happy because his mom is operating the water purification unit…

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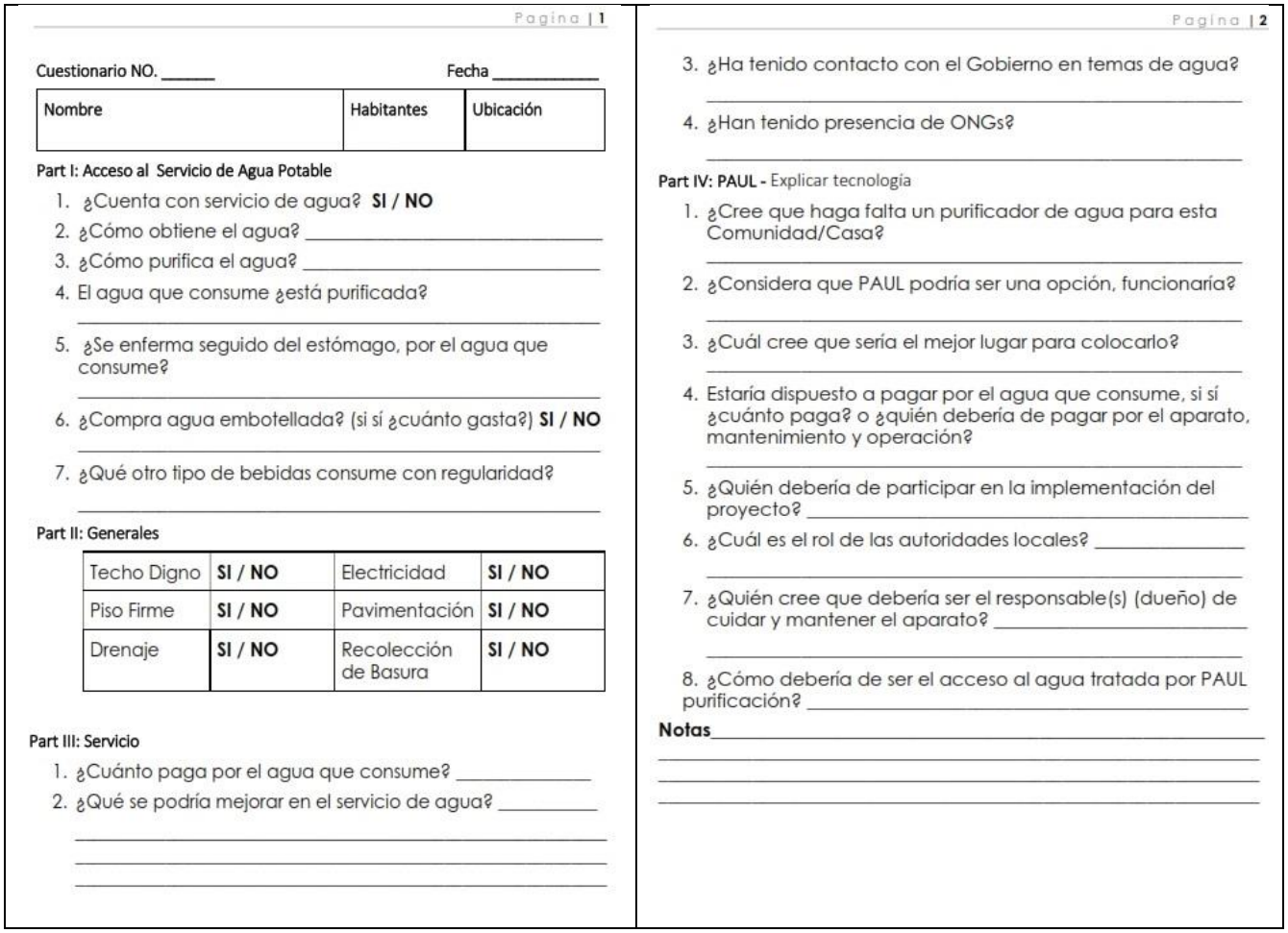
Appendix

Survey Sample



Pagina | 1

Cuestionario NO. _____ Fecha _____

Nombre	Habitantes	Ubicación

Part I: Acceso al Servicio de Agua Potable

1. ¿Cuenta con servicio de agua? **SI / NO**
2. ¿Cómo obtiene el agua? _____
3. ¿Cómo purifica el agua? _____
4. El agua que consume ¿está purificada?
   _____
5. ¿Se enferma seguido del estómago, por el agua que consume?
   _____
6. ¿Compra agua embotellada? (si sí ¿cuánto gasta?) **SI / NO**
   _____
7. ¿Qué otro tipo de bebidas consume con regularidad?
   _____

Part II: Generales

Techo Digno	**SI / NO**	Electricidad	**SI / NO**
Piso Firme	**SI / NO**	Pavimentación	**SI / NO**
Drenaje	**SI / NO**	Recolección de Basura	**SI / NO**

Part III: Servicio

1. ¿Cuánto paga por el agua que consume? _____
2. ¿Qué se podría mejorar en el servicio de agua? _____
   _____
   _____
   _____

Pagina | 2

3. ¿Ha tenido contacto con el Gobierno en temas de agua?
   _____
4. ¿Han tenido presencia de ONGs?
   _____

Part IV: PAUL - Explicar tecnología

1. ¿Cree que haga falta un purificador de agua para esta Comunidad/Casa?
   _____
2. ¿Considera que PAUL podría ser una opción, funcionaría?
   _____
3. ¿Cuál cree que sería el mejor lugar para colocarlo?
   _____
4. Estaría dispuesto a pagar por el agua que consume, si sí ¿cuánto paga? o ¿quién debería de pagar por el aparato, mantenimiento y operación?
   _____
5. ¿Quién debería de participar en la implementación del proyecto? _____
6. ¿Cuál es el rol de las autoridades locales? _____
   _____
7. ¿Quién cree que debería ser el responsable(s) (dueño) de cuidar y mantener el aparato? _____
   _____
8. ¿Cómo debería de ser el acceso al agua tratada por PAUL purificación? _____

Notas_____
_____
_____
_____