Water Access Technologies Based on Traditional Knowledge In Mexico: Obstacles And Strengths

By FLACSO TEAM
María Luisa Torregrosa, Jordi Vera, Karina Kloster,
Beatriz Torres

Abstract
Solving water access for human consumption in Mexico has been a challenge since the Pre-Hispanic period, mainly due to the geographic distribution of water and its hydrological characteristics in the area. Since those days until today, syncretistic process have been taking place to solve water needs emerging amongst the population, these processes included both the introduction of completely new elements and the renaming as well as the redesigning of already existing devices for water manipulation. In this paper two of the following devices are considered to analyze the causes of use and disuse of devices themselves for human water provision. The first device existed just before the Pre-Hispanic period, namely jagüey and refer to artificial rainwater deposits carved in the soil near the hills, houses or buildings. The second one, introduced by the Spaniards and taken from the Arab influence, aims at infiltrating galleries, underground horizontal channels transporting water by gravity as far as reaching the surface as a well spring.
From a multidimensional approach, based upon the analysis of four case studies, two for jagüeyes and two for infiltrating galleries, considering for each technology one case in use and one in disuse, authors identify the analytical dimension that should achieve a better understanding of the issue: deep social differentiation among users of such technology; decision making bodies to mediate differences; technological knowledge and operating culture in relation to the use of technologies; operating culture in relation to maintenance of technologies.
The article explores reproductive forms of technologies by unraveling social and cultural processes which have made possible technology to be used, kept and socially assimilated. The article explores the multidimensional aspects that make water

access technologies as jagüeyes and infiltrating galleries prevail or disappear in time; the role that each dimension, cultural, social, technological and knowledge play in the reproduction of technology or its disuse.

Keywords: Water access, Traditional technologies; Jagüeyes, Infiltrating Galleries, multidimensional approach.

1. Introduction[1]

Solving water access for human consumption in Mexico has been a challenge since the Pre - Hispanic period in Mexico, mainly due to the water characteristics and geographic distribution in the area. One amongst the ways use to solve water access since the Pre-Hispanic period was the jagüey simply known as artificial rainwater deposits, carved in the soil near the hills, houses or buildings. With the arrival of the Spaniards during the colonial period some of the previous technologies used to access water merged with the colonial experience brought from overseas which produced what some authors have called a 'mestizo architecture'. Icaza (1991), p. 244, note 77. Cited by Castro, E. (2006).

The infiltration galleries is a technology that was introduced in Mexico at the time of colonies, which refer to underground horizontal channels able to transport water by gravity as far as reaching the surface as a well spring. Infiltration galleries technology, also called qanats or interconnected wells, is a millenary technique invented in the Middle East and used in the Near East and North Africa. Nowadays in México it is a

[1] The present work was part of the European Commission project ANTINOMOS:"*A knowledge network for solving real-life water problems in developing countries: Bridging contrasts"*. Detailed information can be found in the reports included in the references.

traditional technique that some local populations use for water provision.

This syncretistic process included both the introduction of completely new elements such as the norias (waterwheels), infiltration galleries and the renaming as well as the redesigning of already existing devices for water manipulation such as wells, aljibes (cisterns), jagüeyes and, of course, aqueducts built along the styles of the Iberian Peninsula. Similarly, bath- and wash-houses, troughs of stone and fountains, new materials such as lead and glass, new methods for water purification represent the introduction of a water universe that was completely new to the indigenous. Id., pp. 221-49. Cited by Castro, E. (2006).

The purpose of this paper is to rescue the technological records used for construction, maintenance and the utilization of 2 types of local imported, and later developed technologies in today's Mexico: jagüeyes and infiltration galleries. Based on the analysis of four case studies, the paper will try to establish which have been the main elements favoring the use or to fall into disuse of the aforementioned technologies as the main water source in small rural communities. Moreover, which part of the technological records have prevailed and in which populations targets.

2. Methodology

A central premise that oriented our methodological election for the analysis of the selected case has been the idea that processes of technological appropriation (even when the technological aspects are at the core) would not be integrally understood if social, cultural and economical characters of the system as a whole were not considered.

By this perspective, the starting central thesis for the selection of the methodological approach that will be put forward focuses on the idea that processes of technology appropriation, in order to solve water access to satisfy basic needs, depend on two factors. Firstly, the link between the importance the population gives to needs' satisfaction; secondly, the technological system's adaptation to existing cultural conditions which, then, determines the forms of organization, access and maintenance

around the technology.

In general terms, we have selected the methodology for multidimensional diagnosis to approach our research problem. The selected method helps in identifying the existing social and cultural and technological heterogeneity in the target population. These aspects could explain how the knowledge of different phases for water access, from construction to maintenance, throughout its use, has passed to the population from one generation to another (Parayil, G., 1997).

Based on such elements, we consider that the appropriation process of a specific technology in a targeted population, like the jagüeyes and infiltrating galleries, will have greater possibilities of efficiency and durability if: (1) it responds to a felt individual basic need that is socially recognized as such, (2) differences of perception about that need being assumed and agreed; (3) in the receiving group there are existing cultural elements, already installed and reproducing themselves, which are found in coincidence with technological principles and that enable maintenance and reproduction of the technology in time.

Our experience has proven that a continuous usage of a specific technology for accessing water in order to satisfy needs of a particular social group only prevails and reproduces when the technology represents a culture in action. In other words, it is part of its daily based culture. Consequently, to really get to know technology's reproductive forms it is necessary to unravel the social and cultural processes that made possible technology's appropriation, its social assimilation as well as its use and maintenance.

The 4 case studies, 2 for jagueyes and 2 for infiltration galleries, selected for the present study were located in the Tehuacán Valley, in the south–east state of Puebla (Central México). The 4 case studies share similar climatic conditions: low rainfall (250 a 700 mm/year), scarce and seasonal surface freshwater sources, and arid or semi-arid ecosystems. This region is populated by indigenous communities of Popolucas and Nahuas. Nowadays the people from both areas are very poor and show high migration rates. Two case studies to analyze the traditional technology of Jagueyes were identified in the municipality of

Tlacotepec de Benito Juárez. San Martín Esperilla, a rural community with 989 inhabitants, and San Antonio Zompantle a rural community with 69 inhabitants. In order to study the traditional technology of infiltration galleries two case studies were identified in the municipalities of Tehuacán and Santiago Miahuatlán, both in the State of Puebla. Santa Maria Coapa, an urban settlement with 15 thousand inhabitants, and San Pedro Tetitlán, a small peasant community of 972 inhabitants.

3. Results And Discussion: Cultural Elements To Keep The Technology In Use And The Process Of Knowledge Reproduction

Analyzing the causes of the use or disuse of these ancient technologies, we discovered some main analytical dimensions that can illustrate some ideas over the issue: deep social differentiation amongst users of the technology; decision making bodies to mediate differences; technological knowledge and operating culture in relation to the use of the technology; and operating culture in relation to the maintenance of the technology.

A/- Jagüeyes: A prehispanic technology

The word jagüey or jagüel (jahuel) means raft, trench or well full of water where the cattle is used to drink water. They can be temporal or permanent water reservoirs. It is also defined as lentic epicontinental water bodies; they are close systems without connection to rivers or sea, which only keep the water level due to the rain or to the underground water level. They are small reservoir built on a river bed to store rainwater flowing by the ground's surface.. They were known as and used since the Pre-Hispanic period (Rojas, R. T. 2002).

The Jagüeyes we studied are used to retain and store the rain water that flows on the ground. The storage water in the Jagüeyes is mostly used to water cattle and also for domestic use when the provision of water is deficient or when villages lack of potable water (Galindo Escamilla, 2007: 57).

Because jagüeyes are constructed in places where precipitation is low, they require an area on which the run-off is captured, denominated capture surface. This surface is integrated by hills' slopes covered up by local vegetation or local crops (see scheme in Figure 1). Due to the extension of the capturing surface, it is necessary to conduct water to the Jagüey through channels. There are two types of channels: natural ones, that are dry bed rivers, and artificial ones, made by the users of the Jagüey (local settlers). These last channels are called "atarjea" (culvert/gullies) which are excavated in the hillside or between parcels. Besides water transportation, the "atarjeas" avoid that rain water passes through the cultivated land and erode the soil. The amount of water is conducted to the reservoir that is the jagüey itself, which in some cases have a spillway to remove the surplus water (Figure 1).

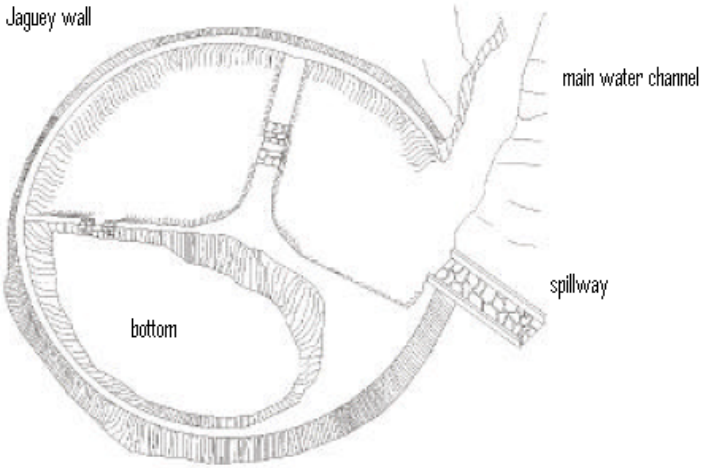

Figure 1. Jagüey general aspect with some of the main structures (Source: Hernández, G. R. and Herrerías, G. G., 2004).

Jagüey recharge in rainy seasons. The rain water up to the hill flows down by gullies/culvert built or improved for that purpose and enters into the jagüey (the storage part). Jaguey reservoir does not let water infiltration because the bottom of the jagüey is

made of pressed soil land "tepetate" (a kind of clay). Thus, in order to get the full of water, a jagüey has to be located where the rain water descends to the storage area. In order to build the jagüey constructors observed the natural water flows and built it where there was more probability of getting more water and preventing the pressure from walls from breaking down.

1) Social differentiation among the users of the technology

The growth of each village has occurred in different patterns. While San Martín Esperilla had a great growth, San Antonio Zompantle was still a very small town. This brings several consequences to the social structure and to the access to water services. San Martin had developed an important differentiation amongst inhabitants according to their income. For this reason a great variation in the water access capacity of the community and its people had developed. For instance, there are several differences in the inhabitants, those who have more than 20 thousands liters of water storage capacity –which gives the chance to buy a water tank- and those who don't have any storage capacity; those who have piped water installed in their house and those who can have access to market to obtain bottled water to drink.

This differentiation in water access has an impact on the community organization. Meanwhile, in San Martin a problem with the atarjeas maintenance is starting– due to change of productive activity of their people or in other cases because land owners do not live anymore in the places where they are located-, all inhabitants of San Antonio are somehow involved in the use and maintenance of the jagüey, so the jagüey is a community responsibility, and for that, there is a community organization according to it.

Furthermore, social differentiation among water consumers in San Martín, have different technology perceptions. They think – to say the truth- that the jagüey's water is polluted. On the contrary, in San Antonio Zompantle jagüey is not only still being used as the principal source of water but also it is considered as the better water they can get.

2) Technological knowledge associated to the construction, maintenance and use

a) Construction

In San Antonio Zompantle interviewers still remember that their grandparents built the jagüey. One of the older interviewers specified the date of construction to be around 1936. This fact is very important because people feel the jagüey as their own, as it is their own construction.

In contrast with this experience, there is not a precise construction date of the Jagüey of San Martín. Apparently, interviewers affirmed that it was built in 1699, during the "hacienda" installation. When the revolution came and took over in the land division the ejidos were created and these people assaulted them and the jagüey started to be a community good.

We can think that the difference between appropriation and construction of the technology brings different perceptions of the technology, for instance in San Antonio they feel more as "they own" it.

However, in both cases there is not an extended knowledge about technical data needed to reproduce the technology. They have a very poor or no knowledge at all about technological principles for its construction or more specific technological functioning details. Perhaps, this absence of knowledge can be explained because it is a practical knowledge, or because, in fact, it is in disuse.

b) Practices for technology use and maintenance

The majority of Jagüeyes are for a community usage; this is why the social organization is important, for the use and maintenance of the jagüey. The use is not restricted, neither in quantity of users nor in quantity of water for each one, but all users have to cooperate to keep the jagüey working.

The Jagüey water is used until it runs out and if that occurred, then water of another Jagüey would have been used.

Maintenance tasks are related to removing the silt from the bottom of the jagüey and to reinforce its borders. Furthermore, the main inlet canals are cleaned and the rubbish removed in order to prevent it from reaching the jagüey.

In both communities there is a person in charge of technology; he is in charge of the surveillance, organization and distribution of those tasks related to the maintenance of the jagüey, and to manage supports for its improvement. He is designated by people of the town through an assembly.

Organization activities imply fundraising (cooperation) among the users, trying to obtain the necessary machinery, communicating activities, establishing the amount and type of cooperation required, and naming the treasurer. The amount of money for the cooperation depends on the amount of Jagüey water used. The amount is divided "amongst all users according to the number of animals that each one owns".

Maintenance tasks of the jagüey are done in a common/public way through the system of "faenas" (equitable tasks divided amongst users of the jagüey). These tasks consist mainly of taking out the excess of mud from the storage area, that is the bottom of the jagüey. The Jagüey has walls which need continuous maintenance, to reinforce them by putting the mud from the bottom of the the wall and pressed it in order to compact and seal it.

The task of removing the silt from the jagüey bottom is shared among st the families living in the village (around 300). Each representative family has to remove silt from an area of approximately 2m.long by 1.5m wide by 1.5m deep. The removed soil is added to the borders, an interviewee refers that approximately 5 tons of silt are moved totally.

Maintenance tasks are done in dry seasons when the jagüey dries out, around March. These tasks of maintenance are one month long. The maintenance of the gullies depends on the landowners. There is not a regulation to force the owner to keep working the culvert, but it is important for them to keep away the rain water running to avoid erosion.

In San Antonio Zompantle, about two years ago people had the machinery support; the utilization of the machinery had reduced the duration of tasks and has distanced its periodicity.

c) Knowledge and Improvements

In recent years, San Antonio Zompantle jagüey has had several and important improvements with the support of the federal

government. In recent years a maintenance task with machinery has been made with the support of the federal government to remove excessive mud from the bottom of the jagüey and with it to reinforce the jaguey´s wall. This support was made on the condition that the people from San Antonio had to afforest their land with maguey plants, plants that are used to make a drink. It seems that the government is going to continue supporting the community for these sorts of repairs.

They also participate to a project of the National Commission for the Indigenous Development (CDI), that included several reforms to the jagüey such as the construction of a biofilter to purify water; the construction of a surplus water exit and the construction of a dam with accommodated stones *(presas de gavión)*, that has the function of retaining the mud and small stones that would flow towards the jagüey.

Meanwhile, in San Martín Esperilla, reparation was made four years ago, when the jagüey wall broke down due to rainfall's excess. In that circumstance, people organized very quickly and repaired it. At the other hand, according to a interviewed people, an expansion was made several years ago, but it is not possible to confirm that information.

2) Decision making bodies to mediate differences

In San Martín Esperilla the jagüey is identified with two main organizations: the community that is in charge of taking care and maintaining the reservoir, and the ejidal commission that is in charge of supervising and coordinating the communal tasks (*faenas*). Supervision tasks are continuously done throughout the year, as they need to monitor the jaguey´s use by the dwellers.

The main organizations in San Martín Esperilla are those related to the ejido. In the dwelling there appears to be a connection-relation of a town ejidal responsible and the ejidal chief of San Marcos. Periodically, when there are issues to be dealt with, ejidal meetings are organized.

Furthermore, there is a recently created water committee. The water committee is in charge of monitoring the future drinking water project that should also benefit neighboring villages (like San Antonio). According to interviews to key informants, the

project is being directly implemented by the State governor and the municipality. The deep well that should provide water has already been identified in the near municipality of Cuacnopalan. The main pipeline network is already in place and the necessary pumps have been installed (there is a 200 m height difference between the village and the well). The only remaining issue to be dealt with is the distributional network in San Martín Esperilla.

3) Operating culture in relation to the technology maintenance and improvements

To organize the community tasks (faenas), inhabitants organized a meeting where they divide tasks and where a commission is appointed to supervise works.

The task division is done depending on the size of families or the animals they own. The bigger are the families, the bigger is the cattle they own, and much work is then required. Older people are dismissed of doing these tasks.

There is also a surveillance system to guarantee the fulfillment of those tasks needed for jagüey maintenance. The person in charge, as stated before, is appointed by the people through their right to vote during the assembly.

Carrying out the community tasks (faenas) is a compulsory task for those using the jaguey´s waters with no interest on how water is used for (this means all the inhabitants are actually involved in these tasks). In cases when tasks are not fulfilled, the monitoring committee issues fines or penalties. In some cases, a household animal seized until tasks is carried out. Generally speaking, there are not any major problems in the organizations of tasks, the interviewee refers that only during the implementation of those agreements some problems might raise, however, the ejidal committee is in charge of solving those problems. They are in charge of checking out who has not attended and after, they issue fines or penalties in non-compliance cases. Normally, with these sanctions the organization achieves the user's collaboration.

The gradual disuse of the technology produced by the introduction of other types of water access in San Martín Esperilla, means that less people are involved in the maintenance

or in the improvement tasks. More people refer that jagüeys water is polluted because of the growth of the village. Furthermore, some people make contracts with other ones to make their own faena. So, the same technology has different perceptions: whether in San Antonio it represents a way of being public, in San Martín it loses its meaning and purposes.

4) Knowledge deriving from practice: evolution and current status

Due to the introduction of other options of getting water for human consumption (for ex. tap water) in San Martín Esperilla, the Jagüey is getting in disuse. In this case, people use the Jagüey only to water their animals and prefer other options for domestic use. However, since the pipe water is only delivered to the households once or twice a week, people need individual water storage systems and most of them can not afford it. In latter cases water from jagüeyes is used for domestic consumption. Also, the high cost of pipe water makes it impossible to use it for their animals; therefore jagüeyes are still used for watering cattle.

With the introduction of other options on water services in San Martín, fewer people are involved in the maintenance of the Jagüey and culverts. Thus, the social organization for the maintenance of the Jagüey is disappearing and also some of the culverts have disappeared due to the lack of maintenance.

As knowledge is associated to practices, in San Martín Esperilla each user has a different level of technological knowledge. In some cases there is a middle level and in other ones it is a middle – high level knowledge. The level of knowledge is related to the use of the technology. Generally people have good knowledge of socio-historical dimension of the jagüey. How it is used, what are its problems, when maintenance was made, and when maintenance is needed and so on.

Only in few places – such as San Antonio Zompantle- where piped water is not still available, people use jaguey's water for human consumption. In San Antonio Zompantle the technological knowledge of users, according to our

characterization, is on the range of medium and medium high[2], in this case the knowledge level is directly related to its use, they know how to maintain it, how to use it, who is to built it, we could say it's a knowledge that is more related to the social and historical dimensions of the technology.

If we agree that a prevailing culture is what maintains a technology alive, we can say that in the case of San Antonio, this is happening in the use and activities of maintenance of the technology, meanwhile in San Martín the technology is almost in disuse. However, the decreasing capacity of reproducing the technology in a long term, expressed in the lost knowledge of the basic elements has required to built a jagüey and has made us think that we are facing a culture in extension.

B/- Infiltration galleries: a colonial technique with ancient roots.

Infiltration galleries were introduced in Mexico during colonial times and nowadays this is a technique which is still in use in some areas. The technological components are very simple (see scheme in Figure 2). The purpose is to dig a horizontal tunnel with a gentle slope that will lead underground water resources, through the force of gravity, to a permanent artificial surface spring, a deposit or an irrigation system. This main tunnel or

[2] Two stages of knowledge were identified; the first stage (general knowledge) was to know if the interviewee had heard about the technology and if they knew that such technology provided them with drinking water. A second stage evaluated the specific knowledge in relation to the technology: the history of its origins, the uses dwellers gave to it, its material character and the knowledge they may have on the existing forms of organization around its management. With those two stages in mind five categories were established. 1) Low level. The user does not have any kind of general or specific information about the technology: 1) Low level. The user ignores its existence or functioning; 2) Low-Medium. The user has a general knowledge of the technology; 3) Medium Level. The interviewee had a broad general knowledge and also some information on specific issues of the technology; 4) Medium-High. The interviewer had both general and specific knowledge but could not deepen much on the organization and technical information. 5) High. The interviewee had complete general and specific knowledge, which is they knew about the technical elements for the construction, operation, maintenance and the organizational social forms around the technology.

gallery has vertical wells called "*lumbreras",* wells whose purpose is to illuminate, to favor gas exchange and to extract materials during the construction and subsequent maintenance works.

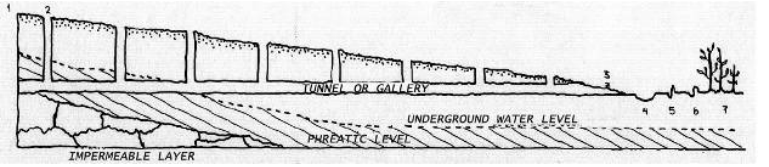

Figure 2: Transversal cut of an infiltration gallery

(1)Aluvión Deposits, (2) Wells or lumbreras, (3) Open Pitch (4) Jagüey or deposit, (5) Coated Channel, (6) Non-coated Channel, (7) Irrigation parcels (Source: Campos et al. 2000).

The tunnel of an infiltration gallery is a horizontal opening of 1.8-2 m high and 0.6 to 0.7 m wide, penetrating into the phreatic level and receiving infiltrations and underground water from the "veneros" (veins) while following the natural land slope until it reaches the surface.

There are several places in Mexico were infiltration galleries have been built, specially where "travertino" soil exist, such as Tlaxcala, Tehuacán, Tepeaca and Acatzingo (Puebla), Saltillo, Coahuila etc. The most documented and known infiltration galleries in Mexico are those present in the Valley of Tehuacán, were archaeological, ethnographical and ethno historical research has taken place (Palerm, 2004).

Even though today these technologies are still in use, the development of this kind of community technologies was threatened for several centuries and it is still the case. The introduction of new land property arrangements during the conquest favored the creation of *haciendas* which broke the existing social organization apart in favor of the management of community water technologies. Pre-Hispanic techniques were suitable for optimal water use in unitary systems but did not adapt themselves to the new social organization regime which divided the area in several isolated units - the *haciendas* - pertaining to different owners. At the same time, the new domination structure on the indigenous population destroyed

the social organization model which had successfully operated for the agricultural production.

1) Social differentiation among users

The two analyzed case studies portray several differences that would result in more or less successful use of such a technology throughout the time.

At one hand, we have the case study number one carried out in the urban town of Santa Maria Coapa. There are two main water sources providing water to its dwellers through a public network: an infiltration gallery and a deep well. This two water sources have provided water to town for more than 25 years.

When revising the historical sources of the village, we have noticed that the area of Santa Maria is relatively old, as population registration is dated back to the end of the 19th century. At that time the village obtained its water from shallow wells-springs. During the mid 20th century there were several public hydrants in the village that supplied water to cover domestic needs. One of the hydrants at that time obtained its water from the case study infiltration gallery, which seems to have been built among 1958 to 1968. During those years, the main use given to water obtained from the gallery was irrigation. Later on, the water obtained through the infiltration gallery was pumped to an elevated tank to provide water for domestic purposes to the town's growing population. It is important to point out that in this area there are at least 2 other infiltration galleries in use, but the latter have been mainly used for agricultural purposes[3].

Due to the continuous population growth, water scarcity started to be a serious threat. In 1981, with a population of about 6 thousand inhabitants, the necessary steps to build a deep well were taken. Once the deep well was constructed, it provided with enough water to cover the domestic needs of the population, so the infiltration gallery was not used as a domestic water source for a while, being crop irrigation as its main use. It was not until 1996 that the local government, aiming at covering

[3] In the past there were two other galleries which have now dried out.

the domestic demand of urban dwellers, decided to buy part of the water obtained through the gallery for the organization in charge, the Water Society (more details of this organization can be found in further sections). It was during that time that the water obtained from the gallery was once again connected to the network, providing water to the southern areas of the town.

At present, the local government is searching for new water sources to satisfy the domestic water demand and some studies about how to drill a new well have been carried out without promising results in the short term. It is important to point out that today the water obtained from both sources (the gallery and the well) can only provide an intermittent service.

The results of this study show that this ancestral technological form is still fully operative and functional, providing a discontinuous water service to at least five thousand inhabitants. Moreover, there are still several organizations taking care of maintenance tasks and conceiving improvements for its correct functioning. A key element in the survival of this technology has been the knowledge component of the technology, which, in the specific context of this case study, has favored its use as a drinking water source even though today it may be in the process of disuse due to the threat of several knowledge related elements which will be further analyzed.

At the other hand, we have the case study number two, in the village of San Pedro Tetitlán. There are two main sources supplying water to this peasant community: a deep well and the water obtained from the so called filtrating wells (in Spanish *pozos filtrantes*). At present time, water flow coming from a previously built infiltration gallery are not significant any more.

The history of water in this second case study is old. The first oral reference about the existence of an infiltration gallery in the town refers that it was built at the end of the 1940s for agricultural purposes. Since not so much water was obtained from it, it fell into disuse. At that time we ignore how the dwellers obtained their drinking water.

Towards the decade between 1960 and 1970, water for human consumption was provided by a jagüey or was transported from a near-by community. Around that time the village obtained

another water source, which is still in use and provides most of the volume of the water consumed for human intake, the so called filtrating wells' water. The inhabitants need to carry the water from these wells with buckets or other recipients as these wells are not connected to the water network.

Even though the provision of water in sufficient quantities has always been a problem to this community, towards the end of the twentieth century the problem aggravated due to the scarcity of rainfall in the area. It was during this scarcity times that the dwellers started thinking about reactivating the previously constructed infiltration gallery to obtain water for human consumption. Even though several studies confirmed that the gallery didn't have such a potential, for several years dwellers developed some maintenance tasks and carried out some works (retention dams), with the help of a local non governmental organization in order to try and retain a greater amount of water. The present results on the amount of water obtained from this works are not too hopeful.

The results of this study show that this ancestral technological form, even though it never really provided a great amount of water, was a relevant water source at some point of the village history (specially during the rainy seasons), having several organizations that took care of its construction, maintenance and operation (firstly known as a Water Society and afterwards changing into a local water committee). However, as it occurs in the present times, the organization that previously looked after the technology is not operating any more and the supplied water flow is not significant: we consider that this technology is in disuse.

2) Technological knowledge associated to construction, maintenance and use of this technology

a) Construction

The construction of the first case study infiltration gallery was a very hard and uncertain activity that started 40 to 50 years ago. In this period several entrepreneur peasants collaborated voluntarily in order to obtain water to irrigate their crops. Several interviewees participated in the construction, directly or through

a family member. It was through the construction works that the water rights were achieved (a certain amount of monthly hours of water service per partner) once the Water Society was constituted. These rights are inherited to descendants once partners passed away.

The construction of the second case study infiltration gallery initiated around 1947 by its Water Society who initially searched for water to irrigate their crops. The gallery belonged to partners who cooperated for its construction. Local dwellers knew where to build it because they observed that water drained from the mountain at one specific point and that was the place where they started pitting. Once the location was identified, they started digging with the help of a candle and a thread. At that point the main tunnel was dug with the help of tools like peaks, taking around one week to dig 1-1.5 meters. However, the gallery did not cover the water flow expectations as the ground appears to be too permeable and the water easily infiltrated through. The gallery fell into disuse and the Society dissolved. Approximately during the 1990s the gallery moved to the organization in charge of community lands.

In Mexico the construction of infiltration galleries, in very exceptional cases has been supported by the federal government (Campos, 2000). This kind of infrastructure has normally been constructed and operated by "sociedades de aguas" (water societies) which represent a scheme of local social organization which operated, at some point, in both case studies and which will be further analyzed.

When local communities pretend to start the drilling of a new gallery, according to regional practices, they hire two or more workers dedicated to this kind of activities that in the region are named "poceros", that is well diggers. Water localization is normally done through traditional mechanisms, with the help of a "varista" (stick man), a person that by means of a "pirul" (local tree) stick tries to search sites where underground water flows. In recent years, organized groups tend to ask for hydrological studies in order to determine the course that underground waters take.

b) Practices for technology's maintenance

Once the infiltration gallery is built, maintenance works that are required are basically conceived to remove the rubble that could potentially obstruct the gallery. This procedure is considered as simple as it is done through the lumbreras. The majority of times these works are done by Water Society members through *faenas* (communal tasks), when the gallery requires it, without an established periodicity. Another maintenance work done to the gallery is to remove the tartar which accumulates in the walls where the water infiltrates. The maintenance tasks are very important for the correct functioning of the technology, for that more water can be obtained from it.

Only in some occasions are the maintenance tasks done by external members of the Society which have a more complete knowledge of the galleries, the so called pitman *(poceros)*. These are specifically hired with the money which is collected from all the Water Society members. These types of complex jobs are done by a specialized labor force.

c) Improvements

While providing a remarkable amount of water to Society's partners, the main gallery of the first case study or its structural elements have not suffered from any major improvements in the last years, other than the inclusion of structural steel brackets to avoid landslides. Another minor modification has been the drilling of 10 meters into the main tunnel after that a small landslide event occurred.

On the other hand, the unsuccessful infiltration gallery of the second case study has had, since the beginning of the XXI century, several major modification phases where dwellers have tried to rehabilitate and reactivate it. Around the year 2000, a pipe was placed up at the beginning of the main tunnel in order to minimize water losses in order to transport most of the water to a water storing deposit. It was then that the community asked an external agent in the figure of an engineer, for a feasibility study that could expand or revitalize the system to provide water for the town's inhabitants. After that technical studies were developed, it was concluded that the gallery didn't have any potential to cover those expectations.

However, due to the lack of alternative sources of water and being affected by a severe drought, dwellers decided to organize a local committee to make some maintenance works in the gallery. This was constituted by 4 members of the community and it operated for about 1 year, approximately between 2003 and 2004. Rather than implementing or developing any work or major improvement, the group focused in cleaning, preventing landslides and fixing walls.

At the same time the committee, with the help of a local NGO, built several retention dams (*presas de gaviones)* to prevent erosion and favor water infiltration. This action was linked to a much broader project this organization is implementing on the ecological management of the river basin. Even though the infiltration gallery should have been indirectly benefited by these works, the scarce rainfall affecting the area has avoided conclusions whether dams actually would work or not.

2) Decision making bodies to mediate differences

In case study 1, there are mainly two administrative bodies-organizations tightly related to the infiltration gallery, the local drinking water committee and the Water Society, both are conceived as spaces for knowledge reproduction about technology.

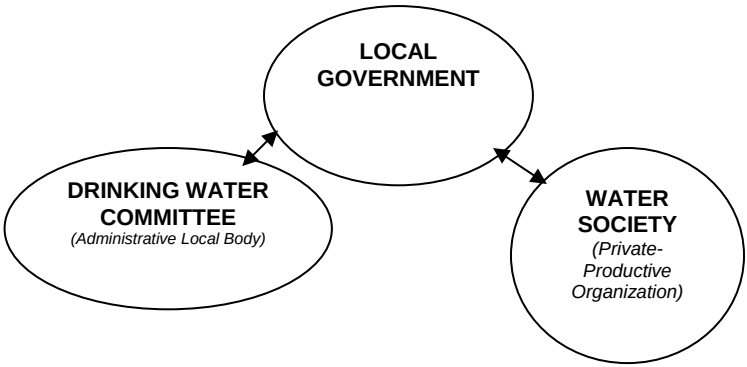

Figure 3. Main organization bodies related with the infiltration gallery and their relations.

Santa María Coapa Drinking Water Committee (the water utility)

is an administrative body of the town's local government that was constituted around 1985. The drinking water committee interacts with the municipal, state and federal counterparts.

The Committee is constituted by 8 members, selected through a communitarian system of "*cargos*" (communitarian responsibilities / jobs) where both women and men can participate, even though women's participation is normally minor. The actual president of the committee is a person with a broad experience in public posts. The functions of the committee are diverse: water chlorination, water management, water distribution through valve management and tariff collection. The relation of the committee with the infiltration gallery technology is relatively recent. Since 1996 the auxiliary board bought part of the water services (which are not water rights) from the Water Society. The agreement is that the committee would have monthly obtained 284 hours of water from the gallery and for that service the local government must have paid 0.8 US$ per hour.

The second important social knowledge organization in case study 1 is Water Society which was founded around 1968 and later integrated by 29-35 partners, of which 11 are descendants of the Society promoters. The water usage rights were acquired by the original builders of the gallery more than 50 years ago and were further inherited by partner's descendants. Furthermore, buying and selling of water rights occurred only later on. Through this mechanism, the drinking water committee acquired some hours for the town's drinking water provision. Partners shared out the total amount of available hours per month (748 hours) with the local government (284 hours that are used for domestic consumption) and partners (460 hours being used for agricultural purposes). Each partner owns a permanent amount of hours (rights). This is the resulting sum of the original distribution of rights during the gallery construction and the amount of hours the partner has bought or sold. For every hour of water service that the partner receives there is an equivalent cost due to Society: it is about 0.8 US$.

For what concerns partner responsibilities in the water association which make the Water Society work, members have

to contribute with physical activities (maintenance tasks) and economic contributions when specialized maintenance task need to be carried out (to pay pitman salaries or buy the necessary materials). The economic contribution per month is not constant and depends on the community-society expenses.

The Water Society has an executive board constituted by a president, a secretary, a treasurer, a manager and 4 speakers. An organizational characteristic of the Water Society is that individuals are invested with an honorific role since none of those receives a salary for participating at the executive body and these posts are based upon rotation. Water Society members need to attend their monthly meetings (otherwise they will be fined).

As we can observe, the organizational arrangements around the use of this first case infiltration gallery is highly complex and involves an important number of members of the community. The institutional arrangements around the technology are fully operative nowadays. This does not occur with the second case study, that of San Pedro where most of the previously existing organizational arrangements have disappeared. An important cause for this disappearance is that there are no matters to be disused around the technological system as this does not work as planned in the past.

When the gallery had been constructed, users had to agree on economic contributions, tasks, etc. At that time, a Water Society was created on the basis of an urgent need. However, once the objective of finding water for irrigation had not been fulfilled, the Society dissolved. In the 1990s, the gallery was granted to the members of the community's public lands who did some very limited maintenance tasks to see if they could obtain some water. Later on, members of the commons donated the gallery to the local government around the year 2001 which is still today responsible for it.

The last relevant organization around this second case study was created in 2004 when inhabitants decided to create a committee to perform maintenance tasks. This committee was formed by 4 members that worked voluntarily in that job. Works of the committee lasted until 2006, when the community decided to

quit any further works in the gallery (they had already found an alternative source of water in the deep well) so the committee broke up.

3) Knowledge derived of the practices: evolution and current status

Two stages of technological knowledge were identified: a first stage called general knowledge and a second stage named specific knowledge Around this two stages we have 5 levels of technological knowledge that inhabitants may own: high, medium-high, medium, medium-low and low depending on the knowledge level of its several technological dimensions.

In case study 1 (Santa Maria), practically all the interviewees have heard about infiltration galleries even though not as many of them received water through this technological system. In other words, not all of the interviewees know how to use this technology. Most users have a medium-low general knowledge level of the infiltration gallery.

The specific knowledge of users is directly related to their membership to the Water Society. Those who have had a public position in the local administration (especially in the local water committee) have a wider knowledge of the infiltration gallery and its functioning. This greater specific knowledge amongst members about the water committee is explained by the greater interaction this organization has with the Water Society (for the settlement of agreements, for the payment of water rights, etc....) so they become familiar with the nature, functioning and threats to the infiltration gallery. The knowledge that stakeholders have about the gallery is more related to water management issues rather than technical issues. The more technical knowledge is mainly restricted-accumulated in the pitman, which are hired to perform complex repairs or modifications.

As for case study 2, the level of general technological knowledge around the infiltration gallery in the village of San Pedro is mainly lower. The majority of inhabitants have affirmed that they are not supplied with a significant amount of water any longer, partly because there are no maintenance tasks carried out in the gallery and partly because it never really provided a sufficient amount of water. As far as they know, the gallery has not being

used anymore, it is closed or dried out. Another reason for this low technological knowledge level amongst inhabitants is that water (sometimes) obtained from the gallery mixes up with the water from a well in the town's water storing tank. Without an in depth knowledge of the water supply system, they usually relate the water storing tank with the water being supplied (only) by a well, not by the gallery.

In this second case study those that have a broader specific knowledge level are those involved in the construction of the gallery as the labor force (more than 60 years ago) or those that recently participated to the local water committee in charge of maintenance tasks. This specific knowledge has been lost in the community and those that participated constructions as workers have died. Furthermore, the specific technical knowledge on how to plot, design, dig, etc... was always more restricted and usually accumulated in the so-called pitman. In this course there weren't many poceros, therefore, most of them were hired in other localities.

4. Conclusions.

In the present work the intention has been to show the different dimensions that affect the use and disuse of traditional technologies for water access: jagüeyes and infiltration galleries. Nevertheless the incidence is different in each case study. There is not a unique dimension that can explain the permanence or extinction of these technologies, but it is, rather, a set of several factors.

If we analyzed the causes of disuse of the jagüey technology we would have observed that the population growth pattern of each case study was very different. In our case studies, having the level of population growth increased as well as the survival or discontinuation of the use of traditional technology occurred, these dimensions produce effects in two different ways. At one hand, in San Martin, the population growth especially up to the polluted hills led to a situation where the polluted rain water descending from the hills to the jagüey made technology a little

reliable.

On the other hand, this population growth implied an economic and social differentiation of the population resulting in a state of pressure and demand of other water sources; this brought the introduction of other water technologies for human consumption and created different organizational bodies that made the survival of the jagüey organization more complex. Nowadays, not all the population in San Martin receives water from the jagüey, as previously explained. In this sense each day, less people are involved in its maintenance.

Contrariwise, San Antonio keeps population growth at the same level and remains a very small town with the jagüey conceived as the main technology for water access. The population prefers this water not only for immediate access but also as a meantime solution. On the other hand its communitarian organization not merely keeps technology alive but also looks and works to improve it.

In the case of infiltration galleries there are several elements that have resulted in different outcomes on the same technological system. In the first case study, Santa María Coapa, the infiltration gallery delivers the expected-planned outcome, obtaining sufficient water for domestic use. However this case study is not exempted from threats as water quality and the existing complex organization arrangements offers short term challenges that need to be solved. In contrast with this "successful" example, the second case study, San Pedro Tetitlán, does not deliver the expected outcome. The reasons for this failure are mainly technical.

During the analysis of these case studies we were able to recognize the importance of decision making bodies' survival throughout the time in the case of the first case study. In this context, organization systems assume great importance for splitting up water services and complex institutional arrangements which are still in place. The natural organization form in this first case study is the Water Society. In the second case study there was an existing natural organization form, a sort of a Water Society. However, as this case study has proved, dwellers never really obtained water from the gallery or

something that needed to be agreed upon, so that the organization dissolved.

In all cases, jagüeyes and infiltrating galleries, the technological knowledge for device constructions has been carried out by external social forms or have disappeared. In the case of jagüeyes, the local knowledge was lost by the death of the main constructors. In the cases of infiltrating galleries the technological knowledge and operating culture in relation to the construction or the development of improvements is concentrated in the social form of the poceros. The Water Society partners are not the builders of the gallery themselves. This poses a challenge to the reproduction of the technology and the different knowledge aspects throughout the time as well as the independence of this technological system from social forms that accumulate the knowledge around it. The Water Society is becoming more dependent on external "experts". We are observing that in the past knowledge which was concentrated in this social group is today further accumulating in other social forms such as specialized NGO´s that are trying to recover old communal practices in rural areas.

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