# From pre-Hispanic Technologies to Appropriate Technologies

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**Abstract**
This article is about the recollection of the main hydraulic technologies of Pre-Hispanic origins among the Mayan, making emphasis in the cultural aspects of construction and inside a particular cosmic vision. This paper underline the necessity of recapturing technologies of Pre-Hispanic origin for water management and its possible use and application in the present social and environmental context. Also, it suggests political guidelines for the use of the so-called "appropriate technologies", with the aim of developing indigenous communities' general tendencies in Mexico.

## Introduction

Pre-Hispanic technologies reveal an accumulated knowledge purported by ancient cultures about the water behavior. Since the Olmeca civilization we can appreciate hydraulic systems that included puddles, channels, fountain and dams. Each of them referred to the system of Planets and each of them had a diverse use, accordingly, and incorporated a cosmic vision based system that related them to natural resources, the environment, gods and cities architecture. In this work we will, at first, make a cutting of the Pre-Hispanic hydraulic systems managed by the Mayan and move on to the study of possible use of technologies in the current indigenous communities while considering which approach is better for the application of the so-called "appropriate technologies", so in vogue at the present time.

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First paragraph: traditional knowledge of the water amongst Pre-Hispanic Mayan[1]

A wide surface of the Peninsula of Yucatan has calcareous floor and rocket; the orography of the territory is defined by plains with hills lower than 500 msnm and it lacks of significant fluvial currents. For this reason most of its water bodies is found in the underground. The pluvial precipitation oscillates among 400 to the annual 1300 mm. The Mayan towns, since the Pre-classic period, knew how to take advantage of these locations by exploiting underground water resources.

In the peninsula of Yucatan, the lack of superficial water currents, stimulated inhabitants to take advantage of cenotes (watercaverns) and the aguadas or rejolladas, (a kind of ponds). Also, they build rainwater harvest systems.

The number of registered cenotes in the present time is of around 8000. These caverns with deposits of water were strategic for the establishment of villages and cities. The cenotes were part of the ritual landscape of the Mayan cities and they were consecrated to specific rituals: places where inhabited by the Rain God, Chac, as it was represented in sheets of Madrid and Dresden codexes. The Landa bishop already mentioned the rites and offerings in the cenotes which were characterized by sacrifices such as the rain petition which was carried out throughout "times of dry" (Landa, 1994).

The sacred Cenote of Chichén Itzá, for example, is the part of a sacred scenario, defined by a sacbé or white road, which is conjoint to the main square. Near this cenote, they are small structures that "….could have a paper in the previous purification sacrifice rituals" (Gilded Rivera, 2001). This cenote was used for ritual offerings and was later modified and adapted by engineers and Mayan architects:

[1] This section is based in our history study of hydraulic preshispanic, see: *Cultura Hidraúlica y Simbolismo Mesoamericano del agua en el México Prehispánico.* Teresa Rojas, José Luis Martínez y Daniel Murillo. IMTA-CIESA,México 2009.

"The rocky border of the well, especially its southern side, was properly conditioned to such a point that shows a kind of seat line at two levels, perhaps for the audience that participated at ceremonies for having a better accommodation; there was a building made up of two rooms, each one with an entrance toward the east and west, the one which was later modified because the fourth west was transformed into temazcal or vapor bathroom in order to purify victims of sacrifice, and it was also embedded in an irregular platform, almost flown toward the border of the well, from the one which perhaps was ejected to the bottom of the cenote "(Piña Chan, 2003: 88-90).

For the INAH researcher, Tomás Gallereta, the cenotes can be of the following types:

"The most well know cenotes are those in a round way, with vertical walls, in those that it is exposed the aquifer (Ts´no´ot); the most famous example is that of Chichén Itzá. There are other cenote forms where the mouth is with a diameter which is of smaller dimensions than that of the reservoir (called ch´e´n, because they seem wells from the surface) and cenotes-gruts (aktún)... they are also cenotes the depressions with a bowl form locally known as aguada (a kind of pond) (akalché), and lagoons or lakes when they reach big dimensions. In the east of Yucatan many of those dolinas don't reach the phreatic level and they are denominated rejolladas (k´op)." (Gallereta, 2007).

These natural depressions, well-known as wateryponds or rejolladas, used by the Mayan, were natural deposits that the Mayan themselves invented. The archaeologist Renée Lorelei Zapata had found that they could be recovered from stucco to have borders and access roads and they were carrying out maintenance works to remove the soil excess (Zapata, personal communication).

The Mayan applied their engineer knowledge to enlarge and to assure water collection as well as conservation and they carried out true innovations, as for instance cases where inside rejolladas

they built wells used for water deposit once the first ones to be used were dried off (Gallereta, 2007).

But the Mayan also knew how to take advantage of the rain water, by means of flagstones crafts which they received and stored water. Three types of these water stone holders are still existing: Chen haltun, a circular incision made by a deep bowl; Nohaltun, an extended but not deep gondola shape; and Tsóno´haltún, a more wider puddle than other ones. These puddles sculpted by the nature in alive stone are called in Spanish as sartenejas (Méndez, 1999). The Chen haltun was the one that habitually was dedicated for the human supply. The other ones could be used for animal consumption or for agricultural purposes because of the formation of muds.
The perforation of wells was also a means to access the underground water. It is the case of the well located in the place of Komchén, Yucatan, built during the half Preclasic (700 B.C., approximately), in an area where the phreatic mantel is not very deep.
On the other hand, the profit of the rain was not only carried out in places outside the communities and natural deposits were used. A special system exists for the use of house family groups and was denominated as chultún. It is a reception system and storage whose construction was based on the excavating the mother rock by means of a shaped large bottle. Some of these constructions were also used to store seeds, but the difference with the chultunes is found in their shape: it was generally deposits in square form and with several compartments (Zapata, 1989).

Follow the archaeologist Renée Lorelei Zapata (1989 and personal communication, 2007), the basic components of the chultunes consist in: the reception system and pluvial conduction through the roofs by means of canaletas (gutters) and superficial channels directed to the collection area or glides of an civic-ceremonial area; a reception area with the floor smoothed by stucco of around 5 m of diameter, with several stone circles to retain the earth and to filter the water of sludge; the mouth that

is the circular entrance or a plow where it drains the water to the deposit; the neck is the continuation of the armed mouth with stones and recovered with stucco; the camera is the storage deposit that can have different dimensions and forms and can be bell shaped, with large bottle amorphous and vault figures (Zapata, 1989).

There have been chultunes in different Mayan cities of the Classic and of the Postclassic: Chichén Itzá, Edzná, Kabah, Chacmultún, Uxmal and in numerous places. This technology was accessible for the whole Mayan people and it allowed to have water in time of dry. The system probably included wooden constructions to channel the water from the roofs as far as the reception area. Archaeological evidence of canaletas exists in form of phallus that united practical uses of canalization of water and identified symbolic elements with the fertility (Zapata, 1989). The symbolic world of the Mayan was present in all its cultural manifestations, including the built technologies for the reception of water: inside several chultunes they have been zoomorphic and anthropomorphous figure made by stucco showing that there were rites associated to fertility, maintenance and petition of water to the Mayan aquatic numens. Some figures are zoomorphic, as birds, jaguars and frogs (Zapata, 1989), but others are anthropomorphous figures in squatting position, as the opposing ones in Sayil (Zapata, 1989). In these cases the position of the Madrid characters is conformed to some sheets of the Codex (9, 30b, 31a) where Chaac and Ix Chebel Yax are portrayed as expelling water between their legs. This scene type associates with the fertility and it has been interpreted as water was given light (Sotelo: 2002).
According to the latter story, we can affirm that the place where hydraulic infrastructure are located do not correspond to defined spaces for practical utility, but for the natural environment bearing the symbolic layout in the urban architectural design:

"The deposits of water are an important ingredient of the Mayan urbanism. They are of many classes: watery, reservoirs, chultunes, cisterns, etc., but they are all distinguished amongst

them because they are typically civic works, they are made for city services and for their inhabitants and they pass to be part of the general design and of the symbolic circumstances of the global space ".(Gilded Rivera, 2001: 168).

The Mayan cities respond to a semiosis that, without a doubt, it was acquired by a particular cosmic vision that reproduced the old myths of the world creation. The artificial mountains are important elements, the sunken patio or primordial sea, the ball game, the satunsat or labyrinth and all the architectural elements that appear in this cities including boards, inscriptions, monuments of all type and, of course, their hydraulic systems.
That is why the representations of the Chac God in the Mayan cities is connected to symbolism of abundance and they are presented in special spaces. For example, in Kabah (whose splendor is located a.C. among 600-850), it exists (unfortunately today it is all covered up by the cement) a denominated chultún "of Chac", because a pyramid stands in front of him –Puuc style- called Codz Poop whose front wall shows a repetition of mascarones of rain's God. Obviously, the place was dedicated to him: also the steps to climb this temple are mascarones of the same Chac and in their interior part, we can deduce that rituals were carried out where the Rain's God had a main paper. The group space (Codz Poop, associate structures and the chultún) was built to request rain water in abundance.

One of the most representative examples in the symbolic architecture and their interrelation with water are the classic city of Palenque. There is no existence of a hydraulic system that includes channels, four aqueducts, works in their nine streams, mainly the Otolum, 56 springs (French, 2007) and ritual bathrooms. Nevertheless, we observe that the planeacion of the city was made according to tributaries. The hydraulic work of Palenque corresponds to an symbolic vision architecture where the city lives together with water: one of the aqueducts of Otolum's river was built close to the building and, in one of its discovered tracts, there is a crocodile head (that, by the way, it was drawn by Frans Blom, ca. 1922).

The palaces, considered to be as sacred centers par excellence had not merely a hierarchical function, but also a ritual one: Gilded Rivera (2001: 168) indicates that the old name for temples could be kul nah, "sacred house" or "god house", making an reference to rulers' divine power, (the symbolic elements shown in some constructions contain features similar to microcosms) and to the representation of different world strata in the Pre-Hispanic Mayan cosmic vision. From there a special paper of the temple is represented in several Mayan cities: the conjunction with the sky, the inframundo (Xibalbá, like is called in the Popol Vuh) and the world of the men.

In the city of Joy Chan, Sky Knotted, better known as Comalcalco whose architectural splendor reigned during 300 years (500 at the 800 of our era), there is, at the top of the Acropolis, near the well-known structure as Popol Naah, a patio with several ponds, a recipient to store water and a system of superficial channels. We believe that it was a place where rituals related to water were carried out. The presence of a figure in stucco of a zopilote (a kind of vulture) that has a jade bill in the mouth supports this hypothesis. The jade bills represent the encouragement to give birth. The jade, in one of the most beautiful representations in the Mayan art, the king's tablet Pakal, in Palenque, seems associated with Itzamná, the celestial snake, with water, with the corn and with the belt of the own king's of Palenque precious stone.

Returning to the palace of Comalcalco, there were also animal bones that were used as ornamentation and for the elaboration of musical instruments (Armijo, 2006) that support the explanation of a place where they were carried out rituals. We don't deny the possibility that these ponds of water, channels and several deposits (one to circulate and another in a square way) they have been used to carry out therapeutical rites. The use of abundant water for the cure of illnesses, for example, the well-known illness as kakob (kind of a pock), has been documented in The ritual of the Bacabes (1987: 346-347).

The inclination of the building toward the south helps the drainage of the water that has been accumulated in these "pools". Linked to it, under a terrace or patio of this same place there is evidence of a peculiar drainage, with a double meaning: the ducks were made with cooked red mud, designed to couple themselves. This system ejects the pluvial water and it was used for domestic reparation (Moll and Martínez, 2006).
The Pre-Hispanic Mayan technology for the water management was supported by a particular cosmic vision, where the symbol was articulated with a practical thing: there was not a definitive differentiation between the technological use and a semiotic process, amongst mythical things, ritual things and the daily life: the Mayan cities were symbolized spaces and the hydraulic infrastructure didn't escape this conceptualization.

**Second paragraph: knowledge, technology and present times**

As we have seen in the ancient Mayan case, the Pre-Hispanic hydraulic technologies supposed:

a) A knowledge of hydraulics and environment inserted in a cosmic vision.

b) A civilization location close to available water resources.

c) A multiple use of water management: channels used for irrigation, sailing, ritual use, drainage, hydromancy.[2]

d) Technologies for the community and technologies for the ruling elite. The case of chultunes and the case of structures in the Mayan Acropolis proper of the Mayan culture.

[2] A model of multiple water use, by the way, is the old ones Olmecan, attests, through the archaeological evidence, in the cities like San Lorenzo Tenochtitlan, La Venta and Teopantecuanitlan

e) A ritual use associated to sources, deposits and structures for effluents.

f) A connection with a symbolic world that, in some cases, high structures, squares and drainages (case of Comalcalco, for the Mayan or The Sale, for the Olmecan ones) underground channels and aqueducts (Palenque case), reflected the creation myths or of mythical places.

g) technologies adapted to ecosystems and natural conditions: in no other places of Mesoamérica we find chultunes. With this last characteristic we emphasized the technological models by means of which different cultures solved their main necessities and they gave them special significance, in accordance with their cosmic vision.

In this last case, technologies were not homogeneous, in spite of the cultural exchange carried out by the Pre-Hispanic Meso-American towns. Each cultural group adapted itself to its natural environment: that was the reason of persistence of the lacustrine culture in the basin of the Valley of Mexico. Ángel Palerm, Red Teresa and José Lameiras, have referred to the complex hydraulic system for handling the lacustrine bodies of the basin (Palerm, 1973). In the zapotecas zones, for example, we find channels and terraces. In a predominant irrigation area, the Valley of Tehuacán, we find the tecoatl or stone snakes, that is a Pre-Hispanic irrigation system. The different models of used channels make people aware of the technological adaptations to specific environmental conditions, available materials, ecosystems and the cultural system. In addition, it is necessary to mention the stone channels with a Olmecan cover; channels of stone of the peninsular Mayan; channels of mud cooked in the city of Comalcalco, of the old Mayan chontales; the watering channels in Tehuacán, or those used in the hill of the Tezcotzinco.

Also, the hydraulic Pre-Hispanic knowledge comes from a long tradition. Some authors, inspiring on the magnification of the

hydraulic technical disciplines, try to demonstrate that old Pre-Hispanic predecessors had intuitions which took them to prove technological options. We believe, instead, that technological innovations were given by the ancestral knowledge on the hydraulic systems. Perhaps, it is for this reason that technologies became technocratic options since they were to find solutions to social and environmental problems occurring every day in the indigenous towns. There was no chance to recognize other ways of being not other knowledge basis and scopes, nor different approaches able to recognize the cultural diversity as well as technological differences. From the industrial era we have inherited the vision of current technology as a homogenizing tool: transnational companies are given the task of marking the exact size of the compact disks as for instance technologies in a global world tend to uniform and homogenize. However, the outline work contains conventional technology that is water technology.

The question is: what does it happen when we face traditional technologies, alternative or appropriate ones from what standpoint do we look at the technological instrument? There are gaps between local and global technology knowledge and it will be necessary bridging contrasts. It would be important to define what we call as conventional technology and appropriate technology or alternative one.

**The importance of technologies' social adoption and their adaptation to indigenous communities.**

Commonly, the so called appropriate technology or alternative one is the one that has, generally, the following characteristics:

a) it requires little investment;
b) it uses available materials found at the level of community or population;
c) it needs an intense handcraft labour;
d) they are of reduced scale;
e) they can be assimilated and maintained by the social group that uses them;
f) they are flexible and adaptive to modifications;

g) they are used without damaging the environment (Pérez and Zabala, s/f).

When the outline of appropriate technology is used correctly, the three principles that govern the use and technological transfer are:

1) recognition of the importance of users' knowledge;
2) active participation to same technologies;
3) environmental sustainability (Pérez and Zabala, s/f).
4) social sustainability of the technology.

The use that persist when we introduce technological instruments in the current rural communities has to do with a technological adoption and social sustainability according to patters of a specific cultural system. As a consequence, in indigenous communities there is a type of a social organization with specific rules around the use of the hydraulic resources. For example, springs in places tzotziles of the High ones of Chiapas where a blue or green cross (the sacred tree ceiba is related to the indigenous cosmic vision in relation to colors, cardinal points and meteorological phenomena for the Mayan communities) marks a sacred spring and it is divided in three: the first one refers to human consumption; the second body of water is addressed to animals for drinking and the third one refer to clothes to be washed (Murillo, 2005). These situations can lead to different agreements with the regional or community cultural patterns, uses and customs, habits, practical rules and agreements, uses and visions of the nature, ignorance and knowledge of the ecosystems, etc.. For that the participation goes on, it transfers appropriation and possible social adoption of technologies: they are understood carried out of agreement with local cultural patterns. Even in tzotziles local places conventional technology of drinkable water has been introduced, for example, residents carried out the construction and they appealed to gods of water, the anjeles, going through pipes' sections from the spring to its community running water (Murillo, 2005). We will see what happens with the technology used for rainwater collection, that was introduced by local towns' Commission of Development in some tzotziles in the

municipality of San Juan Chamula. We could observe the beginning of this operation in the later paragraph. Another characteristic, proper of the appropriate technology, that is necessary to add is that the long term adoption of such a technology looks for a sustainable social use.

Taken this way, processes of technological water transfer bypass institutional and administrative bureaucracy as well as political decisions in Mexico (on the basis of projects' executions and annual programs), that is to say, a sustainable policy of alternative technologies' application doesn't exist in governmental institutions in Mexico, much less in the environment of indigenous communities.
There is more to add to this: the introduction of this type technology in indigenous or rural communities become obsolete when users, due to cultural changes, finish to use them. There are many examples where situations of technological transfer failed but those cases can be verified "in situ" and it would be necessary to consider how appropriate technologies have become part of an archaeological landscape. In the previous case which mentioned the High of Chiapas, when a community is interested in adopting the technology efforts of validating it in relation to cultural patterns are strongly visible. However, not always elements or codes are evident because they are intangible things and latent issues are difficult to materialized with a pragmatic or bureaucratic focus but we know they are always present. For a transfer of appropriate technologies to be successful it is necessary to have a technology that technically complete the objectives it was built, enabled and designed for, but if users don't adopt it socially in agreement with cultural and organizational patterns, the technology will finish in disuse as far its abandonment.

One of the lessons learnt in a project based on the evaluation of appropriate technologies, carried out with funds and partners of

the European Union (Antinomos),[3] points out that transfer processes have not been socially sustainable and they have not fulfill the recognition of community's cultural processes.
The processes of technology transfer should take into account a minimum classification of technological systems that they are intended to transfer in order to know which are the mechanisms and the methodological modalities to be followed to achieve a socially sustainable adoption. Researchers of the Center of Studies of Appropriate Technologies for Latin America, Pedro Serrano, have mentioned three types of technologies: those appropriate and suitable for other places, those newly created and vernacular ones (Serrano, 1985).

**Case 1. appropriate Technologies suitable for other places.**
Technologies have proved their effectiveness in different contexts and it has been possible to understand that when cultural processes had not been carefully recognized fell easily into homogenization and let technologies be homogenized without caring cultural contexts nor cosmic vision semiotics' contexts (as an example, several projects have been a guide for indigenous towns in Mexico). Often, it has happened that devices could not be adapted to environmental, social and cultural realities and could spread differently ignoring cultural diversities thus, producing multiple realities. Usually it has been focused on conventional technologies (hose, tube, key, deposit) more than innovation through the social participation of the involved groups. For example, potable water supply has always been, for indigenous groups, as an assisted necessity without considering that water provision should also be seen according to its infrastructural side; in practice and from the technological adoption's standpoint this has been contradictory. In other words, in a yaqui community (works carried out in 1990) was supplied with drinkable water passing through tubes located in the town square that once broken, water dripped out. In that same community, people continued using specific forms for

[3] A Knowledge network for solving real-life water problems in developing countries: Bridging contrasts(ANTINOMOS)

obtaining water, as for example digging a well to obtain water and to carry it in boats and bucks. Without analyzing and evaluating the social and cultural context as well as conditions of the place, of social participation, no sustainable technological appropriation could have occurred.

**Case 2. Technologies of new creation.**
This kind of technologies need to be experimented and implemented as well as adapted to specific conditions of the place they will be applied. This is generally carried out along population's objective and strong participation since it is a process where population is actively involved in the implementation of technological systems and in the achievement of sustainability. Some of the most critical points related to these technologies relate to the fact they need long term testing and need to be contemplated in the ordinary central government program.

**Case 3. vernacular Technologies.**
Technologies of this sort are made up with systems "with memory" that perhaps have been forgotten in some period of history of indigenous communities and that it is possible to recapture it thanks to environmental knowledge, culture and history of certain communities. Another case tested in the state of Campeche refers to a group of researchers who has implemented the recovery of the chultunes (as we referred to a system collection of pluvial water coming from Mayan invention - Zapata, personal communication, 2007), or, the case of aguadas studied before which referred to collection forms and conservation of hydric resources practiced in the Pre-Hispanic Mayan culture. This is still a practice today that has been corroborated in the recent field work in Campeche and in Yucatan. Or the cases of the jagüeyes, in Hidalgo and other states. Or the technological and cultural systems in use, as the case of springs in the High of Chiapas. Interesting is the case showing this type of technologies that have fallen in disuse: in the place Nitjom, remains of grooved wood have been found. The latter use to drive water toward a small stream in tzotzil

public place and were abandoned at some point of history. Although people have been interviewed to have more knowledge about this practice, nobody could tell what was the reason they served for and why these technological systems were dismissed (Murillo, 2005). In this type of technological systems, vernacular technologies generally appear associated to ritual and symbolic ceremonies, as the rain petitions in indigenous communities (already documented by several authors, among those the highlights by Julio Glockner, Johanna Broda, José Luis Martínez, Catherine Good Eshelman, Gustavo Torres, Evon Z. Vogt, Calixta Guiteras Holmes, Johannes Neurath and researchers that have participated in the Atlas of Water Cultures in Latin America and The Caribbean, UNESCO-IMTA, among other).

It is at this point that, with the mentioned examples, we would like to take the argument of the historical use back as well as the issue of knowledge and traditional memory relative of indigenous cultures in order to use them for the construction of viable options apt to obtain, manage and store water by means of a revision of Pre-Hispanic technologies. This is a road to explore but a road were we have some clues, as the mentioned case of the chultunes, or the use of jagüeyes and aguadas; or the gathering of rain water in the sartenejas in the Mayan area that continue to be used at the moment, in spite of the fact that archaeological remains date of Pre-Hispanic times. For example, a chultún containing 28,125 liters could supply water to 125 people during a period of six months (being the driest period of the year) as it occurs for chultunes of the old Mayan city of Labná (Zapata, 1989). A technology carried out along this use could help to face challenges of today's water scarcity.

**Conclusions**

Due to lack of sustainable technological polices' transfer by the government and official institutions in México, ONGs take the lead in supporting interventions, trying to take into account, in many cases, the social, cultural and economic conditions of the indigenous regions. Wrong approaches such as the endowment of water through conventional technologies or the bad

application of alternative technologies are inefficient and inefficacious roads when defining the extent of indigenous community's marginalization with reference to the difficulties to be encountered while supplying potable water and drainage and the indifference towards the issue of water scarcity as well as water bad quality.

According to our argument in this paper, we can affirm that, from the water management among the prehispanic Mayan -or other indigenous cultures - we can take lessons for the transfer technological and to think in a true socially sustainable development to improve the conditions of existence of the indigenous communities. It is not lazy to repeat that it is necessary to take into account to the other one and to recognize that we live in a pluricultural world what means diverse ways to see the reality and of meaning her. We finish with Paul's sentence Watzlawick: "All we have the surprising idea that the world reflects the world in its objective to be this way. And we don't fall in the account that we are us those that we attribute a significance to that world" (Watzlawick, 1995).

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