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Articles

Social innovation and contributions to the water human right in the Mixteca Poblana households

Innovación social y aportaciones al derecho humano al agua en hogares de la mixteca poblana

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Abstract

The contributions of a social innovation (ferrocement cistern) to the human right to water were analyzed in 30 communities in nine municipalities of the Mixteca Baja of Puebla, Mexico. To collect information on two moments of the water environment in the home (before and after the cistern was built), a survey was applied to 221 heads of household participating in a public program. Likewise, direct measurements were made to 221 cisterns to calculate the collected volume of water. Based on the factors agreed in General Observation

No. 15 (2002) on the right to water (articles 11 and 12 of the International Covenant on Economic, Social and Cultural Rights), indicators were established and the results compared to identify changes. The innovation generated the following effects: it increased from 18.3 to 63.2% the storage capacity per household; increased from 97.1 to 100.0% households that have between 50 and 100 liters per person per day; increased from 23.0 to 79.0% on the days the stored water satisfied the needs of the households; increased from 23.5 to 59.3% families that ceased to carry water; decreased from 31.5 to 28.0% families who travel more than 1 000 meters; decreased from 20.4 to 19.0% of the families moving more than 30 minutes, and reduced by 29% the annual cost per payment of water hauled and purchased from water tanker truck and water jugs. It is concluded that innovation caused positive effects on households contributing in some factors of the human right to water.

Keywords: Innovation, human right to water, eco-techniques, water for domestic use, Mixtec.

Resumen

Se analizaron las aportaciones de una innovación social (cisterna de ferrocemento) al derecho humano al agua en 30 comunidades de nueve municipios de la mixteca baja de Puebla, México. Para captar información sobre dos momentos del entorno del agua en el hogar (antes y después de construir la cisterna), se aplicó una encuesta a 221 jefes y jefas de familia participantes en un programa público. Asimismo, se realizaron mediciones directas a 221 cisternas para calcular el volumen captado de agua. Con base en los factores pactados en la observación general núm. 15 (2002) del derecho al agua (artículos 11 y 12 del Pacto Internacional de Derechos Económicos, Sociales y Culturales), se establecieron indicadores y los resultados se compararon para identificar cambios. La innovación generó los siguientes efectos: aumentó de 18.3 a 63.2% la capacidad de almacenamiento por hogar; aumentó de 97.1 a 100.0% los hogares que disponen de 50 a 100 litros por persona al día; se incrementó de 23.0 a 79.0% los días que alcanza el agua almacenada; aumentó de 23.5 a 59.3% las familias que dejaron de acarrear agua; disminuyó de 31.5 a 28.0% las familias que recorren más de 1 000 metros por agua; disminuyó de 20.4 a 19.0% las familias que se desplazan más de 30 minutos por agua, y se redujo en 29.0% el costo anual por pago de agua acarreada y comprada de camión cisterna y garrafón. Se concluye que la innovación causó efectos positivos en los hogares, contribuyendo en algunos factores del derecho humano al agua.

Palabras clave: innovación, derecho humano al agua, ecotecnia, agua de uso doméstico, mixteca.

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Introduction

Water is the most important renewable natural resource for all forms of life on the planet. However, in terms of its quantity, humanity is currently experiencing water stress caused by several factors: population growth, climate change, urban growth, privatization, supply tactics and pollution (Pérez, 2015), as well as poverty, inequalities and disparity in power relationships (ONU & OMS, 2011).

By 2015 the water scarcity already affected 663 million people who remained without access to improved drinking water sources (Semarnat & Conagua, 2017), and it is predicted that by 2025, 1.8 billion people will live in countries or regions with absolute water scarcity (FAO, 2015).

In Latin America 130 million people lack access to clean water in their households, only one in six has adequate supply networks and millions of human beings are deprived of water and excluded from distribution systems (Azar, 2018).

To confront the water crisis, the international community raised awareness that access to drinking water must be framed within Human Rights (ONU & OMS, 2011). For this reason, the Universal Declaration of Human Rights proclaimed the right of every person to health, welfare, food, clothing, housing and necessary social services (ONU, 1948). The right to water was agreed upon in General Observation No. 15, International Covenant on Economic, Social and Cultural Rights (ONU, 2002).

The Organization of American States (OAS) adopted resolution AG/RES.2760 (XLII-O/12) reaffirming the right of States to establish policies on the use and services of water in their territories (OEA, 2013). It was agreed as a goal in the Millennium Development Goals (goal 7.C) (ONU, 2013), and in the objectives of sustainable development (objective 6) (ONU & CEPAL, 2016).

Accordingly, Mexico amended Article 4 of the Political Constitution of the United Mexican States in which the State guarantees access, disposal and sanitation of water for personal and domestic consumption. Article 27 states that the waters are property of the Nation, and grants the municipalities the responsibility of the drinking water service (article 115, III a) (Secretaría de Gobernación, 2014).

However, because there are multiple reports that warn about the problem of water access and distribution, as well as various legal tools on the Human Right to water, States have not had the capacity to guarantee access to water for the entire population of their venue (Salmón, 2013).

In Latin American countries, the ownership of natural resources to the State has been instituted in Political Constitutions, so the State must provide water to the entire population, but this benefit does not reach everyone in the same way (Gentes, 2001).

The foregoing shows that there is a Constitutional Right declared on paper, which through the Guarantee Instrument must become an operable, enforceable and demandable right (Mitre, 2012), for which the State is responsible for providing the means and conditions to enforce them, otherwise it will fall into a Constitutional and/or International illusionism (Azar, 2018). However, even where the State recognizes the right to water in its laws, it does not necessarily translate into automatic compliance with the law (Langford & Khalfan, 2006).

Faced with social and environmental challenges, it is necessary to seek new solutions that allow to face problems with scarcer resources, particularly where climate becomes the main factor of water distribution. This is the case of Mexico, where two thirds of the territory are considered arid or semi-arid, with annual rainfall of less than 500 millimeters (Semarnat, 2016).

Under restrictive water conditions it is difficult to develop any productive activity, especially when there are needs of the vital liquid for domestic and personal use. To support marginalized populations, the Mexican State launched the Strategic Food Security Program (PESA by its initials in Spanish), focused on food production; one of its components is "healthy home", mainly focused on access to water for domestic use.

One of the regions in which the program operated was the Mixteca Baja region of Puebla, Mexico. In a microregion formed by 30 communities of nine municipalities, 521 cisterns of ferrocement (considered social innovation) were built, a more viable alternative in the short term to capture and store rainwater for the drought.

After its implementation it was necessary to know its effects on the beneficiaries, so the objective of this study was to analyze the contributions of social innovation to the Human Right to water, based on the factors agreed by the United Nations in the General Observation number 15, International Covenant on Economic, Social and Cultural Rights.

The concept of social innovation

In general terms, it is considered innovation, the application and use of new ideas, concepts, products, services, practices, methods, etc., with the aim of increasing productivity (Planque, 2002; Amaro, Morales, & Villavicencio, 2011). But this concept is oriented to the companies, the market and the economy, consequently, other authors consider as an innovation the "ability of people to exploit an idea or a new method correctly to achieve a desired effect (material or social). The consequences (intentional or not) of this innovative activity can cause incremental, radical or transformational changes in social life" (Smith, 2017).

Although business innovation is the most widespread for human well-being, there are other innovations that have significant impacts on society and that explain the improvement in their living conditions, which are not necessarily commercial innovations, but rather social innovations, although there is not consensus on its specific meaning (Pol & Ville, 2009).

Social innovation is a complex phenomenon that covers various activities of social innovations, which respond to the needs of the population that are not commercially feasible, due to new combinations of social practices, attitudes and values involving changes in strategies and policies, organizational structures and institutional frameworks (Van der Have & Rubalcaba, 2016). For an innovation to be social, it must improve the economic and social conditions of society; in other words, to improve the quality of life (Pol & Ville, 2009). Collective social innovation originates from social bases, activists, community groups, organizations, etc., where communities control processes and results (Boni, Belda-Miquel, & Pellicer-Sifres, 2018).

Making a differentiation between social innovations and technological innovations, Alijani and Wintjes (2017) consider that the use of technology is of neutral value, and its use does not guarantee the production of social value, since social innovations are not measured by prices of market that determine the exchange value. On the other hand, social innovation is limited spatially and temporally by the diversity of social, economic, cultural and institutional contexts. As a social phenomenon, the pace and direction of social innovation are closely related to the dynamics of social relations.

Windrum, Schartinger, Rubalcaba, Gallouj and Toivonen (2016) consider three areas of social innovation when relating them to innovation for the (service) market: i) social innovation has a social value, driven by principles of inclusion and wellbeing, while innovation for the market is oriented by profit objectives, that is, the creation of economic gain; ii) social innovations seek to empower citizens, while market innovations seek to empower citizens through new roles and relationships and the development of assets and capacities, and iii) social innovations tend to be very local in nature and often codification is difficult, while service innovations sometimes encourage imitation and rapid diffusion of new ideas and practices.

These characteristics coincide with the two basic conceptual elements pointed out by Van der Have and Rubalcaba (2016): social innovations involve a change in social relations, systems or structures, and these changes serve as shared human objectives or to solve socially relevant problems.

In the same vein, Álvarez-González, García-Rodríguez, Sanzo-Perez and Rey-García (2017), consider four dimensions for an innovation object to be considered social innovation: i) be focused on the common good to satisfy or solve social problems, ii) be a collaborative process where all the interested parties participate, iii) it implies an improvement in relation to the previous solutions and, iv) it involves effective changes in the behaviors and social practices in the different levels.

Therefore, innovation of a social nature presents features that differentiate it from innovation of an economic nature, such as: the search for solutions to social problems, rather than the market; the use of the intellectual power of the human, more than the financial one; free distribution, more than the protection of the idea, and its complex nature, rather than technological aspects (Morales, 2008).

In this study, social innovation was considered to be the introduction of the ferrocement cistern for the capture and storage of rainwater. While the priority is rainwater, the sources can be others, such as public mains water, well or river water, water tanker truck, etc.

The term ferrocement, was patented by the French Joseph Louis Lambot, in the year 1855, refers to a material similar to concrete, which is reinforced with several layers of thin wire mesh, such as hexagonal mesh or chicken wire, electro welded mesh or acma , and some pieces of iron, forming a framework that is covered with the mixture of cement, sand, and water (mortar), forming a special structure with a thickness between 6 to 8 cm, where the geometry of the cylinder-shaped cistern gives it a stiffness and adequate resistance for the water accumulation (Mora, Jiménez, Carrasco, & Abarca, 2016).

The human right to water

Based on the notion of Water Security there are two conceptions about water rights; "Those that predicate homogeneity and universality and adopt a vision of rights with regulations focused on the State", which function as a tool and condition to facilitate the exchange and trade of water; and water rights based "on the explicit recognition of their historical specificity and their roots in particular ecological and cultural situations", constituted in the understanding of current norms, practices for local water control and existing power relationships (Zwarteveen & Boelens, 2011a).

The understanding of the State on the Right to Water was agreed upon in General Observation No. 15, International Covenant on Economic, Social and Cultural Rights; bases that the human right to water "is the right of everyone to have sufficient, safe, acceptable, accessible and affordable water for personal and domestic use", to avoid death, reduce risks of diseases, satisfy consumption needs, cooking, personal and domestic hygiene. This right is indispensable and is a precondition for exercising other Human Rights for a dignified life (ONU, 2002).

The human right to water is that "all people have access to the vital liquid and can use it in sufficient quantities and in adequate conditions so that their life needs are met in a dignified manner", so it is an inherent basic right the human being, is common to all, is not subject to negotiation and is inalienable (Azar, 2018).

In a social approach compatible in some aspects with public and community approaches, it emphasizes that human dignity comes first, and that universal access to water sufficient for basic needs is an absolute and non-negotiable priority (Langford & Khalfan, 2006).

From the perspective of the human right to water of indigenous communities and peoples, the Inter-American System for the Protection of Human Rights considers that the right of access to clean and quality water is linked to the property of the ancestral territory, so that existing lands and resources must be protected as a right to their property, so that communities can perform their ancestral customs as a right to cultural life and enjoy a dignified life (Salmón, 2012).

The previous configuration focuses on the cultural recognition of water justice; recognize and respect different ways of treating, organizing and talking about water, based on diversity, identity and culture, granting autonomy to water user communities to build and apply their own standards (Zwarteveen & Boelens, 2011b).

From the worldview of indigenous peoples "water as a universal and community right belongs to everyone and belongs to nobody. It belongs to the earth and to living beings, including the human being. It is distributed equitably according to needs, customs and community regulations, and according to its cyclical availability "(Huanacuni, 2010).

Some Andean countries have included this paradigm in their Constitutions. In the Republic of Ecuador, water is part of the Pacha Mama (Mother Nature) and water is recognized as a fundamental and inalienable Human Right, recognized as the Rights of Good Living (Asamblea Constituyente, 2008; Martínez, 2017).

With the same ideology, in Bolivia the right to water prioritizes its use, access and best usage as a strategic resource in sufficient quantity and quality to satisfy the conservation of life systems, the domestic needs of people and productive processes (Gaceta Oficial del Estado Plurinacional de Bolivia, 2012).

This study expresses both ways of recognizing the human right to water by rural communities located in a water stress condition. However, it is analyzed with the paradigm of the State.

Materials and methods

Characteristics of the study region: the Mixteca baja of Puebla

The study was done in 30 communities in nine municipalities of the Mixteca Baja region, south of the state of Puebla, Mexico:*Tehuitzingo* (Los Hornos de Zaragoza, Cuaulutla, Tecolutla, Tuzantlán y Atopoltitlán); *Ahuehuetitla* (Guadalupe Alchipini, Piedra Blanca y San Vicente El Peñón); *Chinantla* (San Miguel Buenavista, Cuatecontla y Amatepetlán); *San Jerónimo Xayacatlán* (Cañada Estaca, El Cuajilote y Gabino Barreda); *San Pablo Anicano* (San Miguel Tulapa, El Pedregoso y Francisco González Bocanegra); *Tecomatlán* (Mixquiapan, Xantoxtla, Tempexquixtle y Tezoquipan); *Chila de la Sal* (San Pedro Ocotlán); *Tulcingo de Valle* (La Ciénega, Guadalupe Tulcingo, Aguacatitlán y Francisco Villa) y *Piaxtla* (Loma Bonita, Yetla, Santa María y Atempa) (Figure 1).

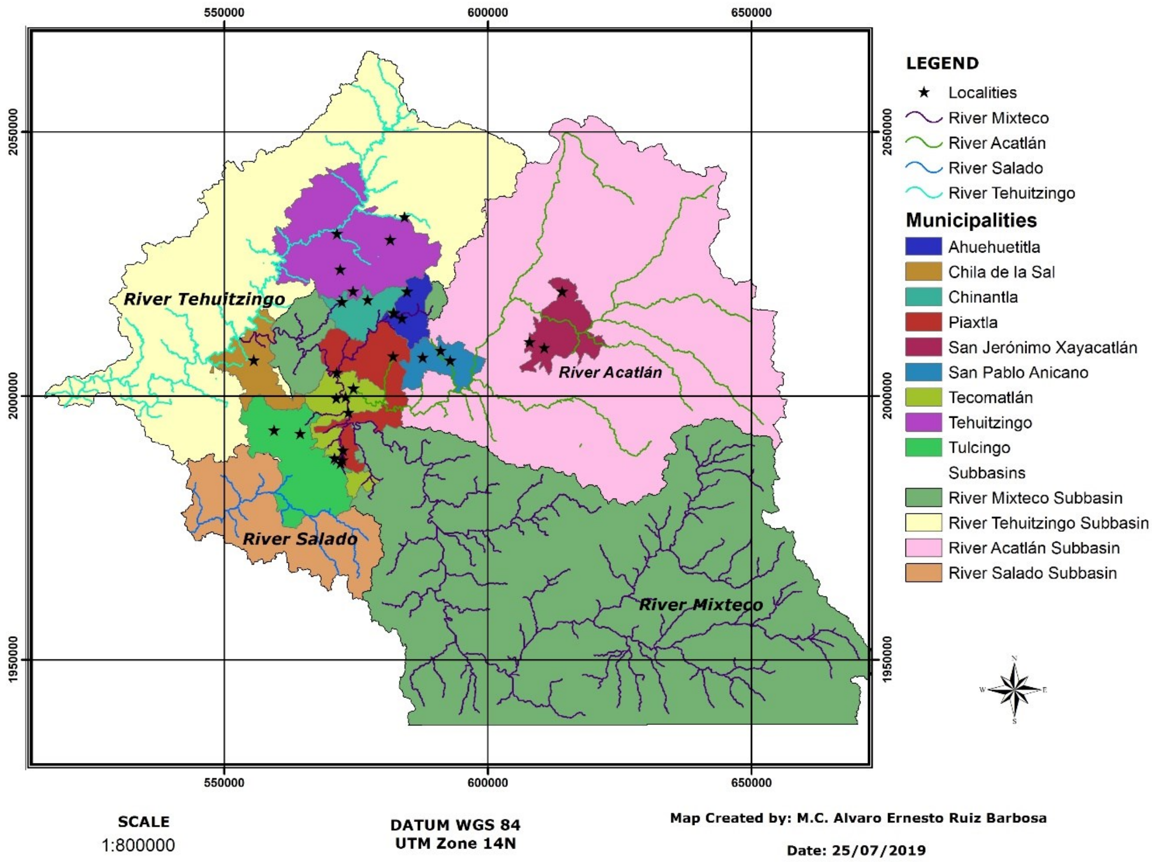

Figure 1. Location of the sub-basins, main rivers, municipalities and communities of the study area in the Mixteca baja of Puebla. Source: Elaboration by Álvaro Ernesto Ruiz Barbosa, with data vector from the National Institute of Statistics and Geography (INEGI, 2015).

According to the National Institute for Federalism and Municipal Development (2010), the study area belongs to the Mixteca baja region of the state of Puebla; it covers an area of 1 677.6 km^2. It is located between parallels 17°06' and 18°30' of Latitude North and 97°50' and 98°33' of West Longitude. It presents three types of climates: the

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Aw0(w) warm sub-humid with rain in summer; (BS1(h’) w(w) semi-arid, very hot and warm (BS1(h’) w(w) and, the A(C)w0(w) semi-warm sub-humid with summer rains. The height above the sea level fluctuates between 700 and 1 200 meters, with rainfall between 600 and 1 000 mm, temperatures between 20 and 26°C and leptosol, regosol, phaeozem and vertisol soils (INEGI, 2010).

In the nine municipalities studied, a population of 43,622 inhabitants (3.7 members) was reported for 2010, and 3 210 households were headed by women (INEGI, 2011).

Research techniques

For the data generation, the following research techniques were applied:

a) Survey, was applied to 221 beneficiary families with a ferrocement cistern with the Strategic Project of Food Safety (PESA by its initials in Spanish), out of a total of 521. To determine the sample size, simple random sampling without replacement was used, and for the identification of its elements random processes were used. The analysis is presented in Equation (1):

$$n = \frac{NZ^2_{\propto/2}\, pn \quad qn}{Nd^2 + Z^2_{\propto/2}\, pn \quad qn} \qquad (1)$$

Where:

n = sample size;

N = population size = 521;

d = precision 0.05;

$Z_{\alpha/2}$ = reliability 1.96;

pn = 0.5; qn = 0.5 (varianza).

Result of n = 221

To collect field information, a questionnaire was applied to the heads of household the 221 cases that resulted from the random process. The questionnaire considered questions about two moments of the water environment in the home: i) context before introducing the innovation (before constructing the ferrocement cistern), and ii) scenario after building the ferrocement cistern, with the support of the strategic project of food safety. To estimate the volume of water in each household for both contexts (before and after the ferrocement cistern), Equation (2) and Equation (3) were considered:

A) Context before the cistern:

$$VTADH = AAA + AAB + AAC + ACCC + ACG \qquad (2)$$

b) Scenario after the cistern:

$$VTADH = AAA + AAB + AAC + ACCC + ACG + ACLL \tag{3}$$

Where *VTADH*, total volume of water available in the home; *AAA*, water carried on foot; *AAB*, water carried on a donkey; *AAC*, water carried in a van; *ACCC*, water purchased from water tanker truck; *ACG*, water purchased from water jugs, and *ACLL*, water collected from the rain.

Information was collected about the access and volumes of domestic water available by family through the hauling on foot, on a donkey, in a van and the purchase of the water tanker truck service, as well as the purchase of a water jug. Regarding the public mains water (piped water), only the frequency was investigated.

b) Direct measurement. To generate accurate information on the ferrocement cisterns and to know the capacity of the water volume, direct measurements were made to 221 cisterns, on the following indicators: diameter, height and length (depth). To calculate the volume, Equation (4) was used:

$$Vc = n * r^2 * h \tag{4}$$

Where: Vc, is cylinder volume, π is a constant (3.14), r, is radius and h, height.

c) Participant observation. The researcher participated in the whole process of planning, execution and evaluation of the project. This form of direct relationship allowed to know and register the situation before and after the construction and use of the ferrocement cistern (innovation) in the home. Tours of the territory, analysis and planning meetings, training workshops and interviews were conducted in order to learn about the problem of water scarcity, supply sources, local conditions, tools, storage works and forms of water appropriation.

Analysis of the information

The information collected through the questionnaire and direct measurement was organized in Excel sheets for later analysis in the Statistical Package for the Social Sciences (SPSS) software. The information resulting from the participant observation was recorded in field notebooks and allowed to complement the data.

Results

Water in the context of the study communities

The study area belongs to the Administrative Hydrological Region IV Balsas (RHA IV Balsas) that coincides with the Hydrological Region (RH) 18 Balsas (Conagua & Semarnat, 2012). Most of the surface is part of the Atoyac River Basin and a smaller part of the Tlapaneco River, within the sub-basin of the rivers: Mixteco, Acatlán, Atoyac-Tehuitzingo and Salado. There is a body of perennial water called Boqueroncitos. The perennial water flows that flow through the territory are: the Atoyac, Mixteco, Acatlán and Tecoloyan rivers and the intermittent ones: El Chilsolote, Laguna Seca, La Trompeta, Tizaac, Valiente, Paredón, Tulapa and El Chahuate (INEGI, 2010).

In the territory there are scarce sources of water and very erratic rainfall, which not only affects agricultural production and livestock, but the satisfaction of water needs for human consumption, personal hygiene and different household activities (washing clothes and dishes, prepare food and clean the house).

The INEGI (2011) reported for 2010, that of the 11 380 households in the nine municipalities studied, only 60.2% had water from the public mains in the area of housing. The situation of the municipalities of Tehuitzingo and Chila de la Sal became more serious, since less than half of the population had water from the pubic mains. However, none of the municipalities had water in all households (Figure 2).

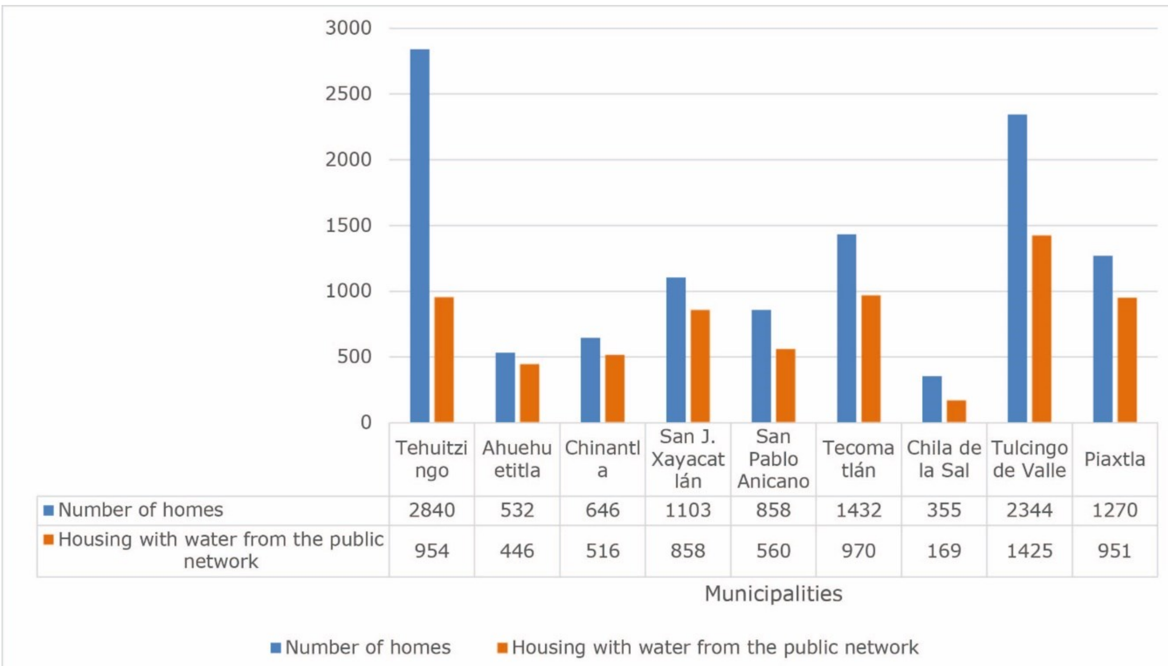

Figure 2. Availability of water from the public mains in the area of housing in 2010, in nine municipalities of the Mixteca baja of Puebla. Source: Prepared by the author with data from the National Institute of Statistics and Geography (INEGI, 2011). Mexico in numbers.

A more recent study made in the 30 communities confirms that 40.3% of families lack piped water, so 76.5% haul water on foot, in donkey and in a van, and buys water from water tanker truck and water jug service (Ocampo & Villarreal, 2014).

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Changes and contributions of social innovation to the human right to water

Changes derived from social innovation

The results (Table 1) show that the innovation (ferrocement cistern) brought social and economic benefits to the families of the Mixteca in different aspects, based on the factors agreed in the General Observation No. 15 (2002) of the Right to Water (Articles 11 and 12 of the International Covenant on Economic, Social and Cultural Rights), which considers the following factors applying in any situation (ONU, 2002):

Table 1. Situation of the families before and after installing the innovation (ferrocement cistern), based on the General Observation number 15 of the United Nations, in the Mixteca baja of Puebla.

General Comment No. 15 of the United Nations	Condition	Indicator	Condition to the optimum (100%)	Situation before innovation	Situation after innovation

Availability (Supply)	Between 50 and 100 liters/person/day[1] (WHO at the ONU, 2010)	Percentage of households that have between 50 and 100 liters/ person/day	100%	97.1%	100%
		Storage capacity per household (liters)	30 000 liters (estimated for the region in the dry season)	5 500 (18.3%)	18 953 (63.2%)
		No. of days that reaches the stored water for household uses	60 days	13.8 (23%)	47.4 (79%)
Quality	Safe water: acceptable color, smell and taste (ONU, 2002)	No. of families that use water from the cistern to drink	221	0	59 (26.7%)
		No. of families that use water from the cistern to drink without any treatment	0	0	24 (10.9%)
		No. of families that use water from the cistern to drink with	221	0	35 (15.8%)

		some treatment: boil, chlorinate, both, strain			
Physical Accessibility	The water source must be within 1 000 meters of the home (WHO, 2003)	% of families that travel more than 1 000 meters	0%	31.5%	28%
	Travel time for collection should not exceed 30 minutes (WHO, 2003)	% of families traveling more than 30 minutes	0%	20.4%	19%
		Time dedicated per day by the family to hauling water (minutes/day/ family)	30 or less minutes	125 (208.3%) 4.2 times more	95 (158.3%) 3.2 times more
		Number of families that do not haul water	221	52 (23.5%)	131 (59.3%)
		Liters of water hauled and/or purchased by family by all means per day (l/fam/day)	14.4 liters (water jug)	363.6	228.2

		Number of people in the family who should not be engaged in hauling water per day	0	2	2
Economic Accesibility	The cost of water should not exceed 3% of household income[2] (UNDP at the ONU & OMS, 2011)	Cost per haul and purchase of water annually ($/year/ family)	Equal to or less than $1 240.92 (Average annual income $41 364.0)	15 701.7	11 151.7
Nondiscriminatio n	Water, services and facilities must be accessible to the entire population (ONU, 2002)	Number of families that have water service in the water mains	221	132 (59.7%)	144 (65.2%)
		Number of families that have public water service throughout the year	221	119 (53.8%)	131 (59.3%)
		Number of families that have a ferrocement cistern	221	0	221 (100%)
Access to information	The entire population has the right to receive	Number of families that received information from the cistern through	221	0	221 (100%)

	information (United Nations, 2002)	PESA (by its initials in Spanish)			

[1] The optimal access is between 100 and 200 liters per person per day (WHO, 2003).

[2] Governments and International Agencies have often established a threshold of affordability ranging from 2% to 6% of total expenditure (OMS & UNICEF, 2017).

Source: Prepared by the author with information of field and ONU (2002, 2010); WHO (2003); ONU & OMS, 2011.

I. Availability. Each person must have a continuous and sufficient supply of water for personal and domestic uses, which considers consumption, sanitation, food preparation and personal and domestic hygiene. The needs of each person can vary and need more water for reasons of health, climate and working conditions.

The World Health Organization establishes that water availability should be between 50 and 100 liters per person per day (ONU, 2010). Other standards consider that 50 liters per person per day of clean water are sufficient for human needs (Gleick, 1996).

For the case under study, 97.1% of households fulfilled this condition before disposing of the ferrocement cistern, a situation that changed 100% with innovation. However, due to the environmental conditions of the region, the volume should be higher. Optimal access should be between 100 and 200 liters per person per day (WHO, 2003).

The storage capacity increased by 244.6%; before installing the cistern, each family had an average of 5 500 liters. With the innovation, an average of 13 453 liters were added, increasing to 18 953 liters per

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family, a situation that led to store a greater volume of rainwater and of water tanker trucks, and an increase 128.6% in the number of families that bought water from the water tanker truck in dry season compared to the previous situation.

Estimates made with families, 30 000 liters are needed for the drier season (March, April and May); before the cistern, the storage capacity was 18.3%, with innovation they have a capacity of 63.2%, that is, it is still insufficient, cisterns with greater volume or another of the same capacity are needed.

Regarding the number of days that the stored water is sufficient (volume of all the deposits), it turned out that without cistern the volume of water is sufficient for 13.8 days and with cistern 47.4 days; that is, it increased 79.0%.

II. The quality. The water for each personal or domestic use must be healthy, and be free of microorganisms or chemical or radioactive substances that threaten the health of people, and have an acceptable color, smell and taste (ONU, 2002). For the case under study, no water analysis was carried out, only the opinion about the treatment they provide to the water (captured in the cistern) that they use for intake was considered.

Opinions show that 26.7% of families use water from the cistern to drink, 10.9% use it without any treatment and 15.8% boil it, chlorinate it, do both treatments or filter it. A study carried out by López, Ocampo and Tornero (2015) in neighboring municipalities to determine if the rainwater stored in ferrocement cisterns fulfil the quality criteria for human consumption according to NOM-127-SSA1-1994, showed that the physicochemical components are within the parameters so that the water can be used for human consumption and other uses. However, it is necessary to perform microbiological studies.

III. Accessibility has four dimensions:

a) Physical accessibility. The entire population must have access to water, facilities and water services. Each household and educational or work space must have access to sufficient, safe and acceptable water, and both the facilities and the service must be of quality and adequate to the conditions of the population (ONU, 2002).

Families must travel less than 1 000 meters and the time for water collection must not be longer than 30 minutes (WHO, 2003). Before the cistern, 31.5% of families traveled more than 1 000 meters and with innovation, the number of families decreased to 28.0%. In the same sense, the number of families moving more than 30 minutes decreased from 20.4 to 19.0%. Having a regular supply of water in the home, would prevent women and children from spending time and physical energy to go collect water from distant sources (ONU & OMS, 2011).

In relation to the time spent to carrying water per day per family, it decreased by 24.0%. Before, each person used an average of 25 minutes per trip, made 2.5 trips, and 2 people were employed, resulting in two hours and 5 minutes per family; later each person used an average of 25 minutes per trip, made 1.9 trips, and 2 people were used, resulting in one hour and 35 minutes per family per day. Currently, each family has an additional half hour per day to perform other activities.

The number of families that stopped hauling water increased from 23.5 to 59.3% before and after disposing of the cistern, respectively; that is, 35.7% stopped hauling water, dedicating time to other activities. Considering that families should not carry water and only buy 14.4 l of water jug for drinking and cooking, the data shows that the liters carried and/or purchased per family per day decreased from 363.6 l to 228.2 l after the cistern. In spite of the above, the number of people per family dedicated to carry water did not change in the families that continued the hauling; that is, two people per family continued to carry water.

b) Economic accessibility. Everyone must have access to water, service and facilities. Direct and indirect costs and charges related to water supply must be accessible and must not endanger other Human Rights (ONU, 2002).

In this regard, families were benefit by reducing by 29% the annual amount for payment of water carried and purchased from water tanker truck and water jug. Currently the savings is $ 4 550.00 per year. Miranda-Trejo (2013) reports expenses for $ 3 600.00 just for the purchase of water from a water tanker truck in the municipality of Tepexi de Rodríguez, Puebla, also within the Mixteca.

c) Non-discrimination. No social group including the most vulnerable and marginalized should be discriminated; everyone has the right to water and water services and facilities (ONU, 2002).

In this respect, a community tank of 40 000 liters was built in a community, supplied with a well for community use and connected to a supply network that feeds the 30 family cisterns of 18 000 l, increasing from 59.7 to 65.2% the service of the public network, and the water availability throughout the year from 53.8 to 59.3% before and after the cisterns were built, respectively. On the other hand, 100% of the participating families installed a ferrocement cistern that they did not have before.

d) Access to information. The entire population has the right to information on aspects of water (ONU, 2002).

In this respect, 100% of the communities and families selected to participate in the program were informed about the food safety program and specifically about ferrocement cisterns. However, by selection criteria not all families were benefited.

Discussion

The conception of the State on the right to water aims to satisfy the needs of consumption, cooking, personal and domestic hygiene in order to avoid death, reduce risks of diseases and for a dignified life (ONU, 2002). From a social perspective, universal access to sufficient water for basic needs stands out as an absolute priority (Langford & Khalfan,

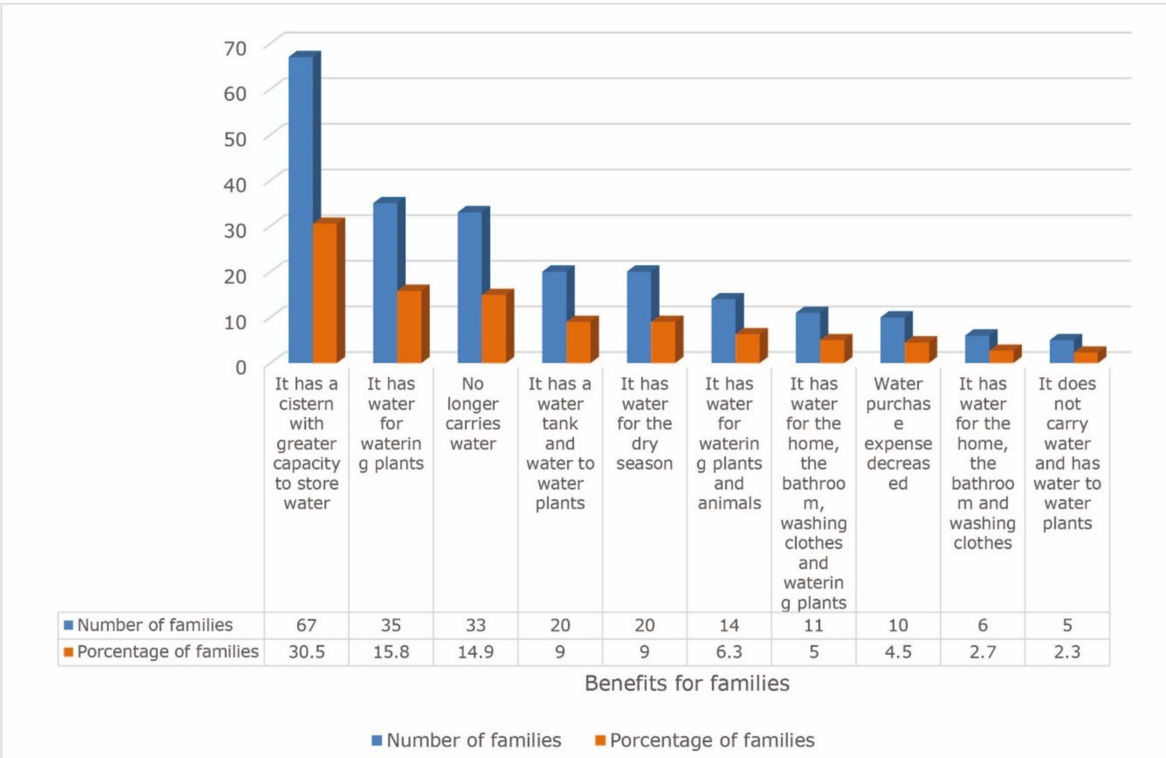
2006) and considers the right to water linked to the cultural life of peoples to enjoy a dignified life (Salmón, 2012).

In this project the two conceptions were articulated; on the one hand, the participation of the State in the management of a project to collect rainwater, providing technology and knowledge, and on the other, the organization, participation and knowledge of the communities to build the ferrocement cisterns, as a social innovation in the region.

Considering the scope of this study, it was possible to evaluate the contributions of social innovation to households and the advances in the human right to water. The main point is that innovation solve relevant social problems and fulfill the needs of the population, showing its benefits in relation to other solutions (Van der Have & Rubalcaba, 2016; Álvarez-González *et al*., 2017).

Based on the factors agreed by the United Nations in General Comment No. 15 (2002) (ONU, 2002), innovation benefited families, contributing to the human right to water.

Of the 221 families interviewed, 100% thought they had received different benefits with the ferrocement cistern. 61.2% thought that the three main ones were: a) to have a deposit with greater capacity in relation to the set of deposits that it had before the cistern; b) have water to irrigate plants in the garden and, c) reduce the hauling of water in the different ways that they did. Other benefits referred to the availability of water for the driest time of the year (March to May), decrease the expense for water purchase, access to water for various household uses and to water animals, mainly goats, cattle, poultry and donkeys (Figure 3). Pol and Ville (2009) point out that an innovation to be social must improve economic and social conditions; that is, improve the quality of life. The results reveal this characteristic of the ferrocement cistern.



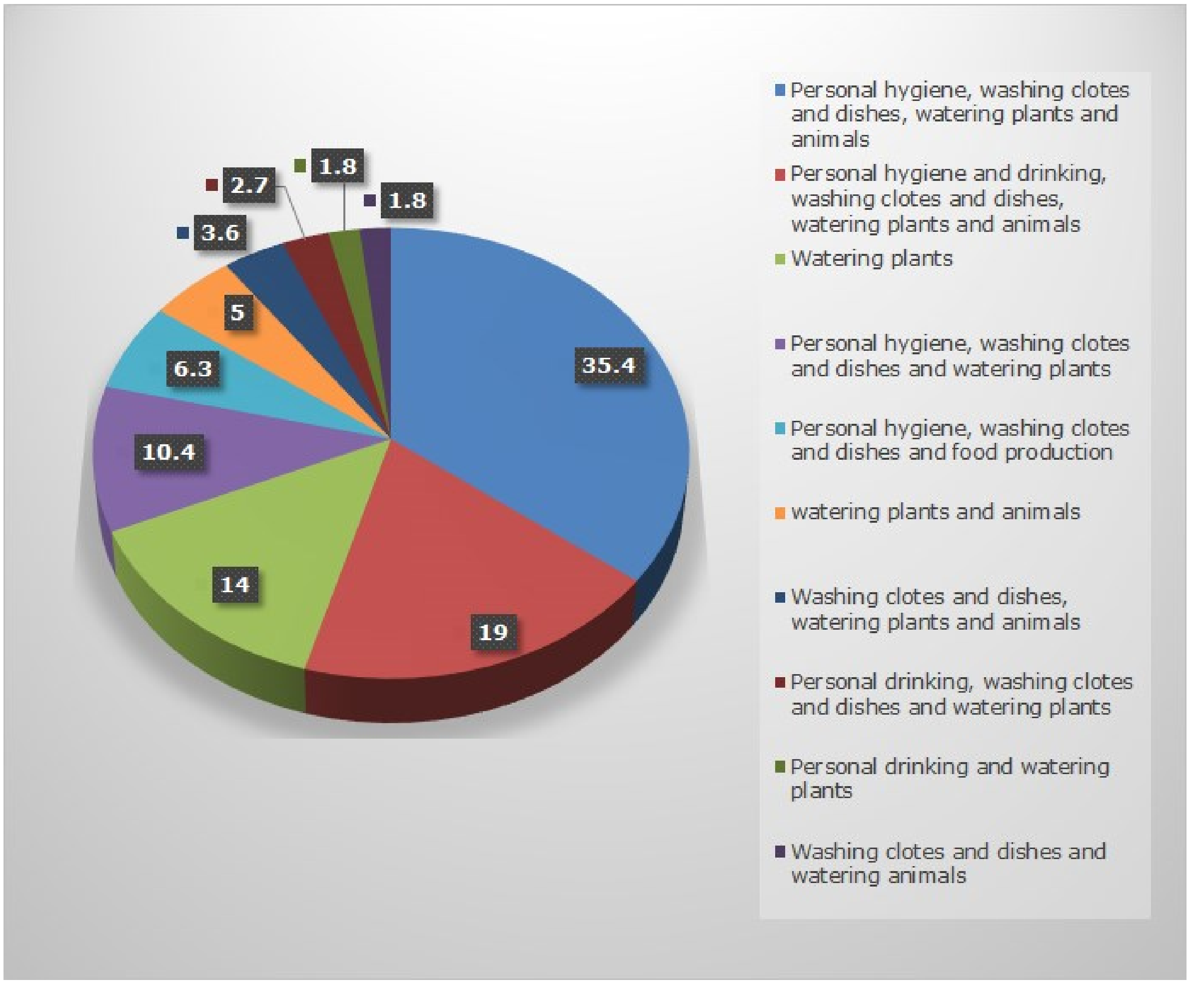
n=221

Figure 3. Benefits of the ferrocement cistern in the opinion of the families (No. and %). Source: Prepared by the author based on field information.

These results coincide with that reported in other studies. Contreras, Vásquez, Zapata and Bustos (2011), registered a decrease in workload (by hauling water) in women and water availability for up to six months, due to an increase in rainwater collection and storage capacity in three communities from Querétaro, Mexico.

For its benefits, social innovation has been promoted by public programs in many countries. In Mexico, it was implemented through the Strategic Food Security Project (PESA by its initials in Spanish), to collect water for the healthy home and food production. An evaluation of the program carried out in ten entities to a sample of 1 078 beneficiaries reported that water availability went from 28.7% with temporary access to 62.9% with availability throughout the year; beneficiaries who stored water increased from 45% before the project to 90% (Sagarpa, 2013). Another similar program was implemented in the Brazilian semi-arid "One million cisterns" for the collection of rainwater for human consumption (PNUD, 2016).

The introduction of innovation aimed to collect and store rainwater for the healthy home; needs forced families to use water in different activities in combination, both for personal hygiene and drinking, household activities (washing clothes and dishes, cleaning and preparing food), watering plants grown in pots and small spaces and for animals. 91.9% of families used it for food production (plant irrigation), 79.2% for household needs, 75.6% for personal hygiene and intake and 64.8% for animal drink (Figure 4).



n = 221

Figure 4. Uses of water stored in ferrocement cisterns in the Mixteca baja region of Puebla (% of families). Source: Prepared by the author based on field information.

Mora, Jiménez, Carrasco and Abarca (2016) point out that water stored in ferrocement cisterns can be used in agricultural production, for animal and even human drink, especially during periods of water scarcity; being a closed system, there is less risk due to contamination of microorganisms.

In addition, innovation caused changes in social relations of cooperation to solve relevant problems of a collective need as pointed out by Van der Have and Rubalcaba (2016). The appropriation of innovation showed the ability of people to explore another method of water collection with social benefits as suggested by Smith (2017), where the use of participatory methodologies influenced to listen to the community about their needs, aspirations and proposals of solution, allowing to know the system of values, beliefs and behaviors for strategic decision making according to Espiau (2017).

However, there is still much progress to be made; It is essential to recognize access to water as a human right, and prioritize policies and guarantee access to clean and quality water (Ribeiro, 2018), especially in semi-arid conditions such as the case studied, with few water sources and low and irregular rainfalls. Gleick (1996) points out that climatic conditions (among others) influence the amount of domestic water needed per person per day, and considers that for rural communities in dry climates it should be between 60 and 80 liters per capita per day. However, the WHO (2003) (without specifying weather condition) recommends between 100 and 200 liters per person per day.

The foregoing raises to continue with more effective projects based on this experience. The appropriation of social innovation was the result of the co-participation of the State and the communities that shared resources and work for the same objective. The latter, based on their experience in community organization, on local technological practices for collecting water, and on power relations built in their historical, ecological and cultural context, took advantage of State supports, generating a new experience to deal with water scarcity.

It is important to consider the limitations of the process and try to change them. On the part of external actors, long administrative procedures persist, a large number of institutional actors, delays in the delivery of construction materials and an excessive evaluation process. In the internal actors there is distrust in the institutions. It is necessary to work in co-participation and in a relationship of trust.

Conclusions

The introduction of ferrocement cisterns for rainwater collecting as an alternative to the water deficit in the homes of the Mixteca region turned out to be a social innovation accepted by families. The increase in water volume in their homes decreased the pressure on access to water and helped to satisfy personal and domestic needs, and in some cases, to ensure water for the production of small-scale plants and for poultry.

Social innovation generated some benefits that suggest contributions to the human right to water, based on the factors agreed by the United Nations in General Comment No. 15 of the right to water.

In the water availability attribute, the storage capacity increased and consequently the per capita volume improved in all households, extending the period of time with water available.

Regarding physical accessibility, the number of families that travel more than 1 000 meters and those that travel more than 30 minutes to collect water decreased; the time dedicated by family to the transport was also reduced, as well as the number of families that hauling water and the volume of water hauling and/or bought. In economic accessibility, the impact was positive by reducing the economic cost by hauling and buying water. Innovation caused incremental and transformational changes in the lives of families.

However, the results assessed as positive by the beneficiaries of the cisterns are insufficient to solve the problem of water stress in households. As long as families continue to haul and buy water tanker truck and do not have access to quality water from a mains water on an ongoing basis, the human right to water will not be met. Hauling on foot or on a donkey in abrupt conditions (ravines, slope, temperature, etc.), with the high participation of women and children, is to violate their rights to a dignified life.

On the other hand, the ferrocement cistern as a new idea associated with water stress, motivated the participation of families (men, women, youth and children), who assumed the commitment to self-build them. A mobilizing element was the support of the State; assisted with construction materials and training, favoring the appropriation of social innovation. In this context, public policies should have a vision of innovation with social effects, facilitating the participation of citizens to promote social development.

Due to the natural conditions of the Mixteca, community and micro regional projects are necessary for the collect, storage, conservation and sustainable management of water. This demands greater intervention of the different levels of government and more participation of the population in planning, execution and evaluation processes of the projects focused on access to drinking water.

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