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PARTICIPATIVE MANAGEMENT OF WATER FOR DOMESTIC USE: THE CASE OF SAN FRANCISCO HUILANGO, TOCHIMILCO, PUEBLA

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ABSTRACT

This study analyzes the governance system of water in the community management model for domestic use in San Francisco Huilango, Tochimilco, Puebla, based on the principles of governance proposed by the Organization for Economic Cooperation and Development (OECD), with the objective of evaluating whether the system is effective, efficient and inclusive, and helping to adjust it where necessary. To that effect, field work and office work were combined to conduct the review of various secondary sources. A total of 68 surveys were applied to social actors and 12 semi-structured interviews directed at key stakeholders. The model studied, a local community adaptation based on integrated water resource management (IWRM) reflected six out of twelve indicators analyzed; therefore, from OECD's approach and with its scoring, the water governance system is not effective and only moderately efficient. However, its capacity to create trust among the population stands out as well as to guarantee that decision making is done from bottom to top, in an inclusive and transparent way. The study's conclusion is that in order to achieve effective and efficient water governance, it is urgent to strengthen the management capacities of rural communities and to promote their social, political and legal recognition.

Keywords: management capacities, water governance, participative management, strengthening, social participation, customs and traditions.

INTRODUCTION

In Mexico, the topic of social participation takes increasingly greater importance in water management. The National Water Law of 2004 promotes this principle because it incorporates the approach of Integrated Water Resource Management (IWRM) by Water Basin. This approach promotes, among other aspects, an institutional arrangement that is increasingly decentralized, with different spaces for social participation in the stages of design, implementation and evaluation of water policies.

Despite the changes and substantial advances involved in the adoption of IWRM in the national water model, the water needs of the population and the ecosystems have not been covered (in adequate quality and quantity) (Caire, 2007; Vargas, 2005; Cisneros; 2008). The protection of natural resources of the basins has also not been covered, nor the real participation of society (Kauffer-Michel, 2008, Kauffer, 2014; Soares *et al.*, 2009). The means to revert this water crisis ought to be based not only on technological innovations and infrastructure, because it is a governance crisis (Vargas and Mollard, 2005; Delgado *et*

al., 2007). The active participation of society is also required in decision-making processes, based on a mature analysis about the differentiation and specificity of the territories (Pacheco and Vega, 2008; OCDE, 2015; Tomé, 2019).

From the perspective of social scientists, the solution to the water crisis also lies on the knowledge and valuation of the self-organization of small localities for the supply of domestic water (Ostrom *et al.*, 1999; Vera, 2005; Cotler, 2007). This is the knowledge that is at the same time subtle and pragmatic, and the organization of peasant communities that allow the construction of water infrastructure and the harvest of broad surfaces of rainfed and small-scale irrigation agriculture (Pimentel-Equihua *et al.*, 2012; Gasca, 2014; Morales *et al.*, 2013; Bernal *et al.*, 2014; Dupuits, 2017). This in addition to the restoration and preservation of natural springs, soils and forests (Ostrom, 2000, Barkin, 2006; Peña de la Paz *et al.*, 2010; Ocampo-Fletes *et al.*, 2018; Tomé, 2019; Escobar, 2020). Also, the multiple forms that these systems adopt, their strengths, the challenges they face, and particularly what we can learn from them to improve water governance systems and management of this resource (Peña de la Paz *et al.*, 2010; Servigne, 2010; Tomé, 2019; Escobar, 2020; Matías, 2020).

As a contribution to this priority issue, this study analyzes the governance system of the community management model of water for domestic use in San Francisco Huilango, Tochimilco, Puebla (Mexico) with regards to the twelve OECD principles on water governance (2015), which are: a) innovative governance; b) regulatory frameworks; c) clear roles and responsibilities; d) integrity and transparency; e) involvement of interested parties; f) arbitration between users; g) monitoring and evaluation; h) training; i) appropriate scales within the basin systems; and j) coherence of policies. These principles provide a framework to assess whether water governance systems function based on the following dimensions of water governance: trust and participation, effectiveness and efficiency, and help in adjusting them wherever necessary. The general hypothesis formulated was that the water governance system of the local water community management model reflects the three dimensions cited.

To fulfill the aforementioned, first the methodology is exposed, and then the physical and social characteristics of the locality in the case study are described. Then, the conceptualization of water governance is presented, followed by the results from the analysis and their discussion, and lastly, the conclusions.

METHODOLOGY

To approach this study, 15 semi-structured interviews were applied in the period of January to April, 2021, to the Drinking Water Committee (DWC), which is integrated by a president, a secretary, a treasurer and 12 assistants or *semaneros*. Also, 68 semi-structured interviews were applied to a sample of representative people from the population served with drinking water. The first instrument provided information about the structure and functioning of the drinking water supply system and the DWC, the 12 indicators of water governance, and the environmental problems.

Meanwhile, the survey was directed at capturing information on the 12 indicators of water governance, the supply of drinking water, the availability and the quality of water, water problems, payment for services, and perception about the public drinking water service, suggestions to improve the service, and participation of people of the locality served through the water management.

To determine the number of surveys, simple random sampling without replacement was used with 95% confidence and 5% error, and all of the inhabitants were considered (1,049). The data were stored in Microsoft Excel®, and central tendency measurements were calculated for the quantitative values. The qualitative data were analyzed through the technique of content analysis.

PHYSICAL AND SOCIAL CHARACTERISTICS OF THE TERRITORY STUDIED

San Francisco Huilango is one of the 10 Auxiliary Boards[1] of the municipality of Tochimilco, Puebla, which has 1,049 inhabitants, according to data from the National Institute of Statistics and Geography (*Instituto Nacional de Estadística y Geografía*, INEGI, 2020). It is located in the central-western part of the state of Puebla, 5.8 km from the municipal township, at altitude above sea level of 1,867 m (Figure 1). In addition to Huilango, the municipality (with Tochimilco as municipal township) is made up of the following localities: San Antonio Alpanocan, Santa Cruz Cuautomatitla, Santa Catalina Cuilotepec, La Magdalena Yancuitlalpan, San Miguel Tecuanipa, Santa Catarina Tepanapa, Santiago

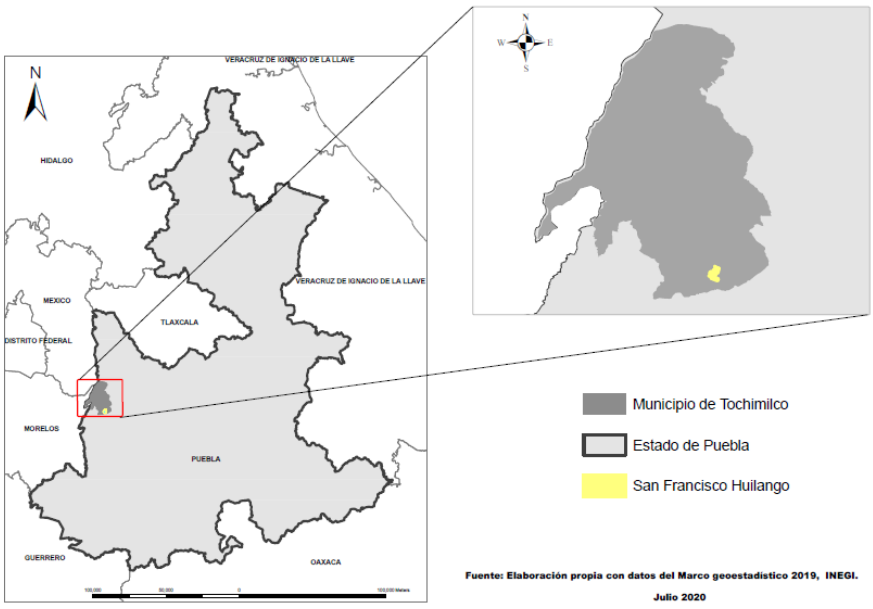

Figure 1. Location of San Francisco Huilango, Tochimilco, Puebla (Mexico).

Tochimizolco, San Lucas Tulcingo and San Martín Zacatempa (Gobierno del estado de Puebla, 2022). From the hydrological point of view, the case study locality belongs to the Administrative Region IV Balsas, specifically in the Administrative Hydrological XVIII Alto Balsas sub-region and the Huitzilac River Basin (Tomé and Villarreal, 2022).

The inhabitants of Huilango have abundant water resources during the rainy season, product of its climate and physiography. The average annual rainfall is 782 mm (higher than the mean annual national and state average of 760 mm), temperate sub-humid climate with summer rains, and temperatures that range from 16 °C to 25.1 °C (INEGI, 2021). Another water resource of vital importance is the Huitzilac River, which is the only source of water for agricultural and livestock production use in the territory. Domestic use is supplied with the underground waters from the Izúcar de Matamoros aquifer with key 2103. This body of water covers a surface of 2000 km^2, and it is located in the south-western part of the state of Puebla. In 2020, it showed availability of 37 879 392 m^3 annually (CONAGUA, 2020), and is in the initial phase of overexploitation, according to data from Bautista (2020).

In 2020, both the municipality of Tochimilco and Huilango showed a low degree of marginalization. From the occupants of households in Huilango, 1.53% was found to be without piped water from the public network and 3.43% without drainage (CONAPO, 2021).

CONCEPTUALIZATION OF WATER GOVERNANCE

The self-management processes of water, in different places and times, take on different characteristics that can be analyzed with the help of different theoretical-conceptual frameworks. This study adopts the concept of water governance defined by the OECD as: The set of political, institutional and administrative rules, practices, and processes (formal and informal) through which decisions are taken and implemented, stakeholders articulate their interests and have their concerns heard, and decision-makers are held accountable for the management of water resources (OCDE, 2015).

The concept of water governance is not a term that refers exclusively to the State or the public sector, but rather involves in a much more complex way the multiple stakeholders with influence in water management (private sector, civil society, local population, indigenous groups, different water users and academics), and combines bottom-up and inclusive processes, at the same time that it promotes constructive relationships between the State and society (Domínguez, 2006; Talbot, 2006; OCDE, 2015).

According to the OECD (OCDE, 2015), strengthened water governance comprises twelve principles that are framed by the dimensions of trust and participation, effectiveness and efficiency, which are mutually reinforced and complemented (Figure 2).

Effectiveness refers to the contribution of governance in the definition of sustainable and clear goals and objectives for water policies in every level of government; also, in the implementation of such policy objectives and in the attainment of the desired

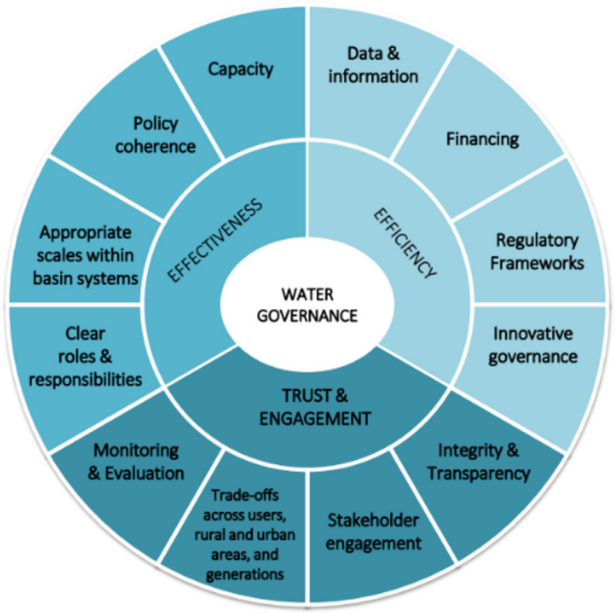

Figure 2. General view of the Principles of Water Governance (OCDE, 2015).

goals. Efficiency is related to the contribution of governance to maximize the benefits of the sustainable management of water and welfare, at lower cost to society. Trust and participation are related to the contribution of governance in the creation of trust among the population and in guaranteeing the inclusion of stakeholders through democratic legitimacy and equity for society in general. Therefore, together with the tree dimensions, the principles have the intention of contributing to the creation of tangible public policies directed at obtaining results, improving water governance systems that they help to manage in order to remediate "too much water", "very little water" or "extremely polluted water" in a sustainable, integral and inclusive way, at an acceptable price and in a reasonable period of time (OCDE, 2015).

RESULTS AND DISCUSSION

Drinking water supply system and water distribution

To carry out water distribution, the Drinking Water Committee (DWC) organized the locality of San Francisco Huilango into three sections: First or low zone at an altitude of 1,820 m, Second or intermediate zone (1,860 m), and Third or highest zone of the community (1,900 m).

The drinking water system (built in 1970) is made up of three sub-systems: supply, storage and distribution network for water. The first is regulated by two supply sources with different volumes in concession. The natural spring "El Ahuacatl" (31,536 m^3 annually) and

the filtering gallery "El Túnel" (51,719 m³ annually), which jointly contribute a volume of 83,255 m³ per year (CONAGUA, 2020); these locations can be seen in Figure 3.

The storage sub-system is integrated by three water deposits, identified as no.2 (49,928 L), no.3 (3,300 L) and no.4 (43,218 L). The first is located in the Second section and the last two containers are in the Third section (Figure 3). The water stored in the three water deposits is supplied by gravity to the PVC and iron pipe network; for this reason, electricity or machinery are not required to comply with water diversion and to make it available to the population in each household's outlet (valve, tap or hydrant) in the different sections of the population. This characteristic of distribution by gravity contributes to decrease the consumption of external energy and to reduce the economic costs for the community. In addition, the network has a pump and valve system. Because of the geographic location of the El Túnel gallery, the water is dispatched by pumping to the containers no.1 and no.2, which supply the households located in the Third and the First section, respectively. Meanwhile, the water from El Ahuacatl natural spring –led by gravity– is deposited in storage tank no.3 and distributed in the households located in the Second section.

It is necessary to point out that installation, operation and maintenance of the sanitation network or sanitary drainage network is responsibility of the Tochimilco Local

Source: prepared by the authors with the Google Maps system. Map: AGEP de San Francisco Huilango, Puebla (INEGI, 2021).

Figure 3. Location of water sources and storage deposits for agricultural and domestic use. San Francisco Huilango, Tochimilco, Puebla (Mexico).

Government, which performs these activities with the support of the Auxiliary Presidency in San Francisco Huilango.

Something else to add is that because the water available is not enough to supply the liquid 24/7 to the entire population, its distribution is done using the batch method, a modality of water distribution every other day that takes place in function of the low water level period. The batches are applied from May to November with a defined schedule of water supply for the three sections of the community. This operative activity is carried out by the 12 assistants or *semaneros*.

An interesting fact is that the local stakeholders have concession rights for the use and exploitation of their two sources of water supply, granted by the National Water Commission in 2008, which shows their effort and interest in fulfilling the requirements and stipulations established by the Commission (CONAGUA, 2020).

Institutional structure for water management

On their own, inhabitants of Huilango are in charge of the extraction, conduction, storage, disinfection, distribution and conservation of their drinking water supply system through an autonomous management model, sustained by two central structures: the Drinking Water Committee (DWC) and the General Assembly.

The DWC was established in 1970 and serves as the central instance for coordination and management; it is made up by a president, a secretary, a treasurer and 12 assistants or "semaneros", based on a scheme of customs and traditions[2]. The directive board thus integrated is chosen annually through direct voting, without gender restriction; the positions are honorary, gratuitous and mandatory. The basic requirements to be part of the DWC are: being between 18 and 60 years old, married or in civil union, not having any physical disability, and being a resident.

As presented in the studies by Aguilar *et al*. (2011), Pimentel-Equihua *et al*. (2012), Sandoval and Günther (2015), Gasca (2014); Rivera *et al*. (2018) and Tomé (2019), the management model studied has an important space for dialogue and social consensus, which is called General Assembly. It is made up by the 15 members of the DWC and the rest of the population served. The members of the DWC are the only ones that have the obligation of attending the Assemblies personally, and there are no sanctions to regulate the attendance of the population supplied with drinking water.

The Assembly is celebrated biannually (August and December) and as many times as the DWC requires it. In this social space, decisions about water management are made for the benefit of the collective good, such as: a) choosing the DWC annually; b) establishing the annual fee for water; c) activities related to building and maintaining infrastructure; and d) receiving the report presented by the DWC in turn. In general, the Assembly meets in the community's plaza, and the invitation is made by loudspeakers a few days in advance. It should be pointed out that all the decisions made in the General Assembly are recorded in the Assembly Minutes.

Principles of water governance from the OECD in the social management model for water

The model of social management for water studied is not only sustained in a well-defined institutional structure, in a space for dialogue and decision making, and in its rules and mechanisms for management, but rather also in specific principles of water governance proposed by the OECD, as shown in Table 1.

From Table 1, it is important to highlight that the social management model studied reflects six of the twelve indicators of water governance of the OECD: 1) clear roles and responsibilities; 2) monitoring and evaluation; 3) arbitration between users, urban and rural areas, and generations; 4) involvement of the interested parties; 5) integrity and transparency; 6) innovating governance; and 7) financing.

It is also interesting that local actors constituted a well-defined institutional structure of water and a space for participation (represented by the General Assembly) to deliberate and make decisions about water management. These agencies do not consider the analytical framework of the OECD, although they are of great relevance, since they could contribute to opening possibilities for the management of other natural resources, as well as the solution of a number of social and environmental problems at the scale of basin.

Similarly, the inhabitants have developed local organizational, administrative, participative and technical capacities for the management of their drinking water supply system, such as expanding the hydraulic network, fixing leaks, making calculations, payments, external negotiations, establishing fees, collection strategies, among others; without forgetting, in addition, that decision making is inscribed in the principles of equity and inclusion.

Something else to mention, as studies by Sandoval and Günther (2015), Rivera *et al.* (2018) and Tomé (2019) have documented, is that this model does not promote the education and training of all the stakeholders involved in water management nor the generation of information and scientific data in water matters. There is also a lack of a regulating framework, which diminishes the effectiveness in the fulfillment and attainment of the rules, norms, agreements and objectives.

With the exception of CONAGUA and the Tochimilco Local Government, the local stakeholders do not establish collaboration links with other government and non-government actors at the scale of basin. It is important to point out that none of the institutions responsible for managing water at a scale of basin have a solid and permanent interaction platform at the community level, so it can be said that water management is not done under the approach of basin.

Another evident deficiency of the model is the lack of connection of local norms and agreements for the resource's management with the national water policy and other sectors, resulting from the inexistence of permanent coordination between government and communities, the lack of spaces for dialogue at the local level, and the omission both of social and community uses of water and local capacities for the management of

Table 1. Description of the water governance principles of the OECD in the management model studied.

		Principles of water governance	Characteristics*	Results
DIMENSIONS	Effectiveness	Training	Adapting the level of capacity of the authorities responsible to the complexity of the challenges of water that they must face, and to the series of competencies necessary to carry out its functions.	The population in general and the DWC have never received any training about issues related to water (water culture, origin of the water sources, water management by hydrological basin, among others) by the DWC itself or the municipality, CONAGUA or the Basin Council. In fact, 87% of the interview respondents ignore the problems around water and the importance of taking care of it, and 93% do not know techniques to save water. The only training received by the DWC is from the Municipality of Tochimilco and it is about the application of chlorine in the water for human consumption.
		Coherence of policies	Fostering the coherence of policies through the efficient transversal coordination, especially between water policies and the environment, health, energy, agriculture, industry, and planning and ordering of the territory.	It is important to highlight that the rules that govern the model studied are disassociated from the water and environmental national policy, since water is not managed under the basin approach and there are no rules related to the care of other resources like soil, air, or environmental education, among other aspects.
		Appropriate scales within the basin systems	Managing water in the appropriate scale(s) within the integrated governance system by basin in order to be able to reflect the local conditions, and promote coordination between the different scales.	Although in Mexico water is managed at the scale of hydrological basin, the system studied does not have any relation to the Balsas River Basin Council or with any of its auxiliary organizations. The only contact is with CONAGUA and the Tochimilco Local Government. The approach to CONAGUA is to manage the renovation of the concession rights of the two water sources. The most frequent negotiations of the DWC with the municipality are the contribution of chlorine to disinfect water for domestic use and training about the application of the disinfectant; requests for economic resources for the construction or improvement of some storage tank.
		Clear roles and responsibilities	Assigning and distinguishing clearly the roles and responsibilities for the design of water policies, implementation of policies, operative management and regulation, and driving the coordination between competent authorities.	The interviews applied to the 12 members of the DWC allowed identifying that they clearly know their roles and functions, which "they have learned about along the way" (E. Sánchez, personal communication, February 24th, 2021). The DWC is in charge of: a) distributing water; b) fixing leaks and registers, cleaning containers, installing new water taps; c) performing external negotiations and diverse payments; d) collecting the established fees; e) being accountable to the Assembly regarding the activities carried out and the movement of funds; and f) solving problems related to the supply. To achieve these activities, each member carries out roles and specific functions and coordinates between each other effectively to develop them. Specifically, the president has the task of leading the assemblies, serving as representative of the system, protecting the documentation, fining debtors and requesting chlorine from the municipality. The secretary writes and organizes documents, elaborates the receipts from charging for water and records the assembly minutes. The treasurer has the responsibility of guarding the DWC funds, charging the fees that have been agreed upon, and exhibiting the corresponding receipts. Each of the 12 assistants or semaneros performs water distribution during one week, so he must fill the three water deposits and apply chlorine to the water.

Table 1. Continuation.

		Principles of water governance	Characteristics*	Results
DIMENSIONS	Trust and participation	Monitoring and evaluation	Promoting the habitual monitoring and evaluation of water policies and of water governance when appropriate, sharing results with the public and performing adjustments when necessary.	Monitoring and evaluation is done in the General Assembly, where, in addition, the results from the activities performed and from fulfilling responsibilities of all the members of the system are shared, and actions are adjusted.
		Arbitration between users, urban and rural areas, and generations	Fostering water governance frameworks that help to manage the arbitration between users of water, rural and urban areas, and generations.	Through their rules, local stakeholders foster the non-discriminatory participation in decision making related with water management, taking into account all the users and sectors of the population served from the three sections, without gender restriction and where all have a voice and vote. In addition, it allows the population served, representatives of the municipality with an impact on water and agriculture and livestock users to identify the barriers for access to quality water service.
		Involvement of the interested parties	Promoting the involvement of the parties interested for them to contribute in an informed way and oriented at results in the design and implementation of water policies.	As indicated previously, at the basin level, CONAGUA and the Tochimilco Local Government are the only government stakeholders that have an indirect impact on water management. It is accurate to point out that the connection with these external actors has been a key factor for permanence and good functioning of the drinking water supply system. At the local level, all the parties involved (agricultural and livestock users, population served and leaders) are included in the adoption of decisions, without gender restriction, and they all have voice and vote. Further still, the agreements reached during the sessions of the General Assembly are defined by voice and vote according to the principle of majority (half plus one) and are mandatory for all the members.
		Integrity and transparency	Incorporating practices of integrity and transparency in all the water policies, water institutions and water governance frameworks for a greater accountability and trust in decision making.	Transparency in decision making and fulfilling agreements and functions of all the members (DWC and population served) are developed in the General Assembly. In this regard, an interview respondent suggests: "In the months of August and December, the DWC presents a report to the General Assembly about the money collected, the expenses and activities performed, and exposes defaulter people to determine what sanction they merit. Therefore, we oversee that the agreements are fulfilled and that the DWC complies with its functions effectively. There have been times when the service has been cancelled for debtors and some member of the DWC that did not want to fulfill their functions" (A. Varela, personal communication, March 12th, 2021) This testimony is evidence that the General Assembly supervises and monitors the fulfillment of this principle, which is regulated by a sanction mechanism.

Table 1. Continuation.

		Principles of water governance	Characteristics*	Results
DIMENSIONS	Efficiency	Innovative governance	Promoting the adoption and implementation of innovative water governance practices among the competent authorities, levels of government and relevant stakeholders.	It is worth remembering that the local stakeholders created an institutional structure with multiple layers of activities, represented by the DWC and the General Assembly; the latter serves as a space for dialogue and social consensus. Something to highlight is that these principles of acting are not mentioned by the OECD, although Ostrom (2000) does underline them broadly. In the General Assembly, decision making is done under the following principles of governance: integrity and transparency, involvement of the interested parties, monitoring and evaluation. In addition to this, the agreements and regulations about water use are established from bottom to top: Before the DWC executes an action or activity, it should be presented first to the General Assembly for it to be approved or rejected (T. Gómez, personal communication, April 9th, 2021).
		Regulatory frameworks	Ensuring that solid regulatory frameworks for water management are implemented and applied efficiently in favor of public interest.	The water management model analyzed lacks a regulatory framework, such as internal rules (formal or informal) that establish the rights, functions, application rules, procedures, incentives and clear and transparent sanctions of all the members. The rules of behavior – sustained on its customs and traditions– are specified in the Assembly Minutes, although not all the users comply with them completely, for example the timely payment for water service: "Because there are no Regulations, we cannot force debtors to pay for the service of drinking water, there is nothing to support us" (J. González, personal communication, March 2nd, 2021).
		Financing	Ensuring that governance frameworks help to mobilize the finances of water and assigning the financial resources in an efficient, transparent and timely manner.	Local stakeholders have mechanisms and procedures to collect and cash money for the construction, operation and maintenance of their water supply system, such as a fixed fee of $400 MXN annually for the water service, a fee of $1400 MXN to install water taps, as well as monetary cooperation to cover the costs of problems in the water infrastructure. These fees are established by the community autonomously. The DWC gathers money on the first Sunday of each month in the locality's plaza. According to the current president of the DWC, the percentage of fee recovery for the drinking water service in relation to the number of water taps (410 in total) is 85%, and the means collected are enough to cover the operation expenses of the system which include covering the electricity costs for water pumping, transport expenses of the DWC members to get the chlorine in Tochimilco, and paying the electricity bill. It is necessary to highlight that allotting financial resources for the maintenance of the system or any other expense is done in an efficient, transparent (in the General Assembly) and timely manner.
		Data and information	Producing, updating and sharing in a timely manner data and information that is consistent, comparable and relevant related to the water issue, and using it to guide, evaluate and improve water policies.	The DWC lacks data and reliable information on crucial topics, such as water quality (microbiological parameters, and physical and chemical parameters), the volume distributed to the population and the effective consumption of water, to mention some, which makes it difficult to gauge the size of the problems, as well as to make decisions in order to solve them.

Source: prepared by the authors with data from the field work carried out in 2021 and the OECD's objective (2015).

drinking water supply systems in the guiding principles of official agencies in charge of water management and official management plans for water resources, as Barkin (2006) describes.

Thus, the study confirms that the model studied reflects one of the four principles that make up the dimension of effectiveness; that is, clear roles and responsibilities. Meanwhile, in the dimension of efficiency two of the four indicators are fulfilled: financing and innovative governance. Concerning the dimension of trust and participation, the four principles are covered: monitoring and evaluation; arbitration between users; involvement of the interested parties; and integrity and transparency.

Based on this and from the proposal by OECD, the water management model studied is not effective and it is only moderately efficient. However, its capacity to create trust among the population and to guarantee the inclusion of stakeholders through transparency, integrity, accountability, democratic legitimacy and equity stands out.

WATER AVAILABILITY

The management model structured this way allows for coverage of the drinking water service in Huilango of 98.4%, which is higher than the one found at the national (96.5%), state (95.5%) and municipal (97.4%) levels, according to INEGI (2020). However, this does not mean that users in Huilango receive water 24 h, seven days per week. Virtually the entire population has the service for four days per week, for an interval of three hours, which is why the amount distributed in each section is different. In fact, 100% of the households store the water in cement tanks, barrels, buckets and water tanks.

Considering that the total capacity of the three containers is 96,446 L, and that this water volume is distributed to 421 households, where a total of 1,049 people live, according to data from INEGI (2020), as well as three educational buildings (one primary, one secondary and one high school), the result is that water availability per person per day is 92 liters. Based on the requirements of domestic water proposed by the World Health Organization (WHO, 2003), the volume available is optimal, because it exceeds the 50 L of water daily considered by this organization for a person to satisfy their basic needs for hygiene and food. The results from the survey confirm the aforementioned; 95% of the interview respondents referred that the water they receive is enough to cover their needs for consumption (drinking and cooking), personal and domestic hygiene (washing clothes and dishes), but is insufficient to water plants, orchards and give water to animals. It is convenient to mention that 5% of the people who describe the water they receive as insufficient are located in the Second section, specifically in the most remote zone from deposit no.1 (to the northeast) and with greatest slope, where there are failures in the liquid's pressure.

To complete the water supply for irrigation of plants and animal consumption, 85% of the users implement the following strategies: a) collecting rainwater; b) reusing water after rinsing clothes and washing dishes to clean the home and courtyard and to water plants;

and c) using water from irrigation channels that run along various streets of the town and is used to irrigate orchards.

Regarding the perception about the quality of the resource, around 85% manifests that water is of good quality, because it is clean and looks transparent; they even use it for drinking and cooking. However, 10% of the remaining population highlighted that the water is not of good quality, since it contains an excess of chlorine, which not only affects its flavor but has also caused gastrointestinal problems, with which they are in the need of purchasing bottled water for human consumption. It should be mentioned that the DWC is unaware of the water quality for human use and consumption, because it has never made any type of quality analysis; therefore, it is not possible to assert that the water that is consumed in Huilango is apt for domestic use.

CONCLUSIONS

The analysis of water governance in the local water management model studied through the principles of water governance by the OECD contributed to identify the good practices (clear roles and responsibilities; monitoring and evaluation; arbitration between users, urban and rural areas, and generations; involvement of the interested parties; integrity and transparency; innovative governance; and financing), and the gaps (lacks a regulating framework, training, data and information, coherence in policies, and appropriate scales within systems in the basin) in water governance. Also, other features of water governance not considered in that analytical framework (a well-defined institutional structure and a space for dialogue and decision making). Although the governance system is not effective or efficient from the proposal of the OECD, local stakeholders have been able to manage, operate and conserve their hydric system since slightly more than five decades ago. This achievement lies in their principles, mechanisms, rules, bidirectional processes, and organizational, administrative, participative and technical capacities developed for the management of their supply system.

The gaps in governance present in the management model studied can be resolved through the promotion of multilevel cooperation between local stakeholders, basin agencies, levels of government, and academic institutions in order to strengthen training in topics related to management and governance of water, to perform permanent microbiological analyses of the water, to define the volume distributed to the users and the effective consumption of water, and to elaborate internal Regulations based on the information contained in the Assembly Minutes. When it comes to water availability, the volume received by each family can be considered as sufficient to lead a dignified life, but it is important and fundamental to develop and manage collective strategies with participation from municipal, state and federal governments, in order to increase the capacity of water storage in the households and the knowledge to make a more efficient use of domestic water.

Something else to highlight is that the management and governance of the water system conceived by local actors is inscribed in their endogenous knowledge, as well as in their

customs and traditions, which makes evident that water governance is highly contextual. From this the importance of water governance systems to be designed or adjusted based on territorial particularities, at the same time as establishing connections at different levels: local, regional, national, global. Therefore, the good practices of water governance found in the model studied could strengthen water governance structures in other localities, and contribute to improve the mechanisms of communication and transparency of the government's water model in Mexico; this is required to move towards a real and effective, participative and integrated management of water.

NOTES

[1]Decentralized agencies of the municipal public administration, dependent on the Local Government of the municipality that they belong to, subject to coordinating with the agencies and organizations of the municipal public administration, in those administrative faculties that they develop within their district (Ley Orgánica Municipal, chapter XXVII, art. 224).

[2]Customs and traditions are the set of practices, habits, rules and tacit conceptions that direct human interactions and relationships with the environment, in correspondence with the recognition of guidelines and ways of behaving by the collective and individually (Sandoval and Günther, 2015).

REFERENCES

Aguilar J, Gómez T, Illsley C, Flores A, Quintanar E, Tlacotempa A, Acosta J, Mancilla S. 2011. Normas comunitarias indígenas y campesinas para el uso de los recursos naturales. Una experiencia de Guerrero, México. Colección Manejo Campesino de Recursos Naturales. Grupo de estudios ambientales, AC. México, D.F. https://gaiaoax.org/wp-content/uploads/2022/08/Normas-comunitarias-indigenas-y-campesinas.pdf

Barkin D. 2006. La gestión del agua urbana en México: retos, debates y bienestar. Universidad de Guadalajara/ Centro Universitario de Ciencias Sociales y Humanidades. Guadalajara, Jalisco, México. 336 p.

Bautista A H. 2020. Sistema hidrológico del acuífero Atlixco-Izúcar de Matamoros: Tendencias hidrológicas. Tesis de maestría. Colegio de Postgraduados, Campus Puebla. 76 p.

Bernal A, Rivas L, Peña P. 2014. Propuesta de un modelo de cogestión para los pequeños abastos comunitarios de agua en Colombia. Perfiles Latinoamericanos 43: 159–184. https://www.scielo.org.mx/pdf/perlat/v22n43/v22n43a7.pdf

Caire G. 2007. Retos para la gestión ambiental de la cuenca Lerma Chapala: obstáculos institucionales para la introducción del manejo integral de cuencas. *In:* El manejo integral de cuencas en México. Estudios y reflexiones para orientar la política ambiental. Cotler AH. (comp); Secretaría de Medio Ambiente y Recursos Naturales–SEMARNAT: México, DF; 2ª. Edición. pp: 195–212.

Cisneros E X. 2008. La gestión del agua a través de los COTAS en México: análisis de su gestión en cuatro estudios de caso. *In:* La gestión de los recursos hídricos: realidades y perspectivas. Tomo 1. Soares D, Vargas S, Nuño RM (eds.); Instituto Mexicano de Tecnología del Agua–IMTA/Universidad de Guadalajara: Jiutepec, Morelos; Guadalajara, Jalisco; México; pp: 257–280.

CONAGUA (Comisión Nacional del Agua). 2020. Actualización de la disponibilidad media anual de agua en el acuífero Atlixco-Izúcar de Matamoros (2103), estado de Puebla. Comisión Nacional del Agua/Subdirección General Técnica/Gerencia de Aguas Subterráneas. 19 p. https://sigagis.conagua.gob.mx/gas1/Edos_Acuiferos_18/puebla/DR_2103.pdf

CONAPO (Consejo Nacional de Población). 2021 Índice de marginación por municipio y localidad 2020. https://www.gob.mx/conapo/documentos/indices-de-marginacion-2020-284372

Cotler H. 2007. El manejo integral de cuencas en México: estudios y reflexiones para orientar la política ambiental. Secretaría de Medio Ambiente y Recursos Naturales. 2ª. Edición. https://agua.org.mx/wp-content/uploads/2008/06/El-Manejo-Integral-de-Cuencas-en-Mexico-segunda-edici%C3%B3n.pdf

Delgado LE, Bachmann PL, Oñate B. 2007. Gobernanza ambiental: una estrategia orientada al desarrollo sustentable local a través de la participación ciudadana. Revista Ambiente y Desarrollo 23 (3): 68–73. http://documentoskoha.s3.amazonaws.com/15605.pdf

Domínguez S J. 2006. La gobernanza del agua en México y el reto de la adaptación en zonas urbanas: el caso de la ciudad de México. Anuario de Espacios Urbanos, Historia, Cultura y Diseño 2006 (2): 273–296. https://agua.org.mx/wp-content/uploads/2019/02/La-gobernanza-del-agua-en-M%C3%A9xico-y-el-reto-de-la-adaptaci%C3%B3n-en-zonas-urbanas-el-caso-de-la-ciudad-de-M%C3%A9xico.pdf

Dupuits E. 2017. Desde las organizaciones comunitarias del agua hacia el territorio latinoamericano: Espacios transnacionales de convergencia y resistencia. *In:* A contracorriente: agua y conflicto en América Latina. Capítulo 12. Vila G, Bonelli C. (eds.); Editorial Abya Yala/Justicia Hídrica: Ecuador; pp: 235–258.

Escobar N C (ed.). 2020. Gestión comunitaria del agua. Impluvium 12: 1–70. http://www.agua.unam.mx/assets/pdfs/impluvium/numero12.pdf

Gasca Z J. 2014. Gobernanza y gestión comunitaria de recursos naturales en la Sierra Norte de Oaxaca**.** Región y Sociedad 26 (60): 89–120. https://www.scielo.org.mx/pdf/regsoc/v26n60/v26n60a4.pdf

Gobierno del estado de Puebla. 2022. Plan Municipal de Desarrollo de Tochimilco, Puebla, 2021-2024. Secretaría de Gobernación/Orden Jurídico Poblano. https://ojp.puebla.gob.mx/normatividad-municipal/item/4237-plan-municipal-de-desarrollo-de-tochimilco-puebla-2021-2024

INEGI (Instituto Nacional de Estadística y Geografía). 2020. Censo de Población y Vivienda del Estado de Puebla. Tabulados del cuestionario ampliado. https://www.inegi.org.mx/programas/ccpv/2020/#Tabulados

INEGI (Instituto Nacional de Estadística y Geografía). 2021. Anuario estadístico y geográfico por entidad federativa. Puebla. https://www.inegi.org.mx/app/biblioteca/ficha.html?upc=889463904847

Kauffer-Michel EF. 2008. Comités de cuenca en Chiapas y tabasco: entre la participación, endeble y el riesgo de politización. *In:* La gestión de los recursos hídricos: realidades y perspectivas. Tomo 1. Soares D, Vargas S, Nuño RM (eds); Instituto Mexicano de Tecnología del Agua–IMTA/Universidad de Guadalajara: Jiutepec, Morelos; Guadalajara, Jalisco; México; pp: 193–227.

Kauffer MEF. 2014. Políticas públicas y gestión integrada de los recursos hídricos: del paradigma a sus concreciones en la cuenca del río Grijalva. *In:* Montañas, pueblos y agua. Dimensiones y realidades de la cuenca Grijalva. Volumen 2. González-Espinosa M, Brunel M MC (coords.); El Colegio de la Frontera Sur/ Juan Pablos Editor. México, D.F; pp: 611-635.

Matías AME. 2020. La política hídrica nacional y sus consecuencias en la gestión comunitaria del agua. Impluvium 12: 28–33. http://www.agua.unam.mx/assets/pdfs/impluvium/numero12.pdf

Morales P, Corrales N, Sánchez R, Mota R, Chana F, Hernández G, Illsley C. 2013. Construcción de consensos para la gestión del agua en comunidades campesinas de la Montaña de Guerrero. Programa y Resúmenes del Tercer Congreso Nacional de Manejo de Cuencas Hidrográficas. Universidad Nacional Autónoma de México; Centro de Investigaciones en Geografía Ambiental, Morelia, Michoacán, México; pp: 89. https://remexcu.org/documentos/cnmch/III-CNMCH-2013_programa.pdf

Ocampo-Fletes I, Parra-Inzunza F, Ruiz-Barbosa AE. 2018. Derechos al uso del agua y estrategias de apropiación en la región semiárida de Puebla, México. Agricultura, Sociedad y Desarrollo 15 (1): 63–83. https://www.redalyc.org/articulo.oa?id=360559614005

OCDE (Organización para la Cooperación y el Desarrollo Económicos). 2015. Principes de l'OCDE sur la gouvernance de l'eau. Acuerdos adoptados en la reunión del Consejo de la OCDE a nivel Ministerios, 4 junio 2015. https://www.oecd.org/fr/gov/politique-regionale/Principes-OCDE-gouvernance-eau_brochure.pdf

Ostrom E, Burger J, Field CB, Norgaard RB, Policansky D. 1999. Revisiting the Commons: Local Lessons, Global Challenges. Science 284 (5412): 278–282. https:/doi.org/10.1126/science.284.5412.278

Ostrom E. 2000. El gobierno de los bienes comunes: la evolución de las instituciones de acción colectiva. Traducción: de Iturbide C C, Sandoval A. Universidad Nacional Autónoma de México/Fondo de Cultura Económica (UNAM-FCE). México, D.F. 395 p. https://base.socioeco.org/docs/el_gobierno_de_los_bienes_comunes.pdf

Pacheco VR, Vega O. 2008. Los debates sobre la gobernanza del agua: hacia una agenda de investigación en México. *In:* La gestión de los recursos hídricos: realidades y perspectivas. Tomo 1. Soares D, Vargas S, Nuño RM (eds); Instituto Mexicano de Tecnología del Agua–IMTA/Universidad de Guadalajara: Jiute-

pec, Morelos; Guadalajara, Jalisco; México; pp: 57–86.

Peña de la Paz FJ, Herrera PE, Granados MLE. 2010. Pueblos indígenas, agua local y conflictos. *In:* El agua en México: cauces y encauces. Capítulo 16. Jiménez B, Torregrosa ML, Aboites AL (eds.); Academia Mexicana de Ciencias. México, D.F. ISBN 978-607-95166-1-1; http://www.coniunctus.amc.edu.mx/libros/El%20aguaenMexicocaucesyencauces.pdf. pp: 455–478.

Pimentel-Equihua JL, Velázquez-Machuca MA, Palerm-Viqueira J. 2012. Capacidades locales y de gestión social para el abasto de agua doméstica en comunidades rurales del Valle de Zamora, Michoacán, México. Agricultura, Sociedad y Desarrollo 9 (2): 107–121. https://www.redalyc.org/pdf/3605/360533091002.pdf.

Rivera MJ, Guevara RML, Tapia ME. 2018. Instituciones comunitarias autogestivas de abastecimiento de agua potable: el caso de Tlaltepango, Tlaxcala. (SP). Nova Scientia 10 (21): 441–474. https://doi.org/10.21640/ns.v10i21.1267.

Sandoval MA, Günther MG. 2015. Organización social y autogestión del agua. Comunidades de la Ciénaga de Chapala, Michoacán. Política y Cultura 2015 (44): 107–135.

Servigne P. 2010. La gouvernance des biens communs. Analyses et études. Barricade: 1–7. http://www.barricade.be/publications/analyses-etudes/gouvernance-biens-communs

Soares D, Romero R, Benez MC. 2009. Las percepciones sobre el agua en la cuenca del Río Amacuzac. *In:* La gestión de los recursos hídricos: realidades y perspectivas. Vargas S, Soares D, Pérez-Peña O, Ramírez AI (eds); Tomo II. Instituto Mexicano de Tecnología del Agua: Jiutepec, Morelos, México; http://hdl.handle.net/20.500.12013/1161. pp: 216–237.

Talbot D. 2006. La gouvernance locale, une forme de développement local et durable? Une illustration par les pays. Développement durable et territoires. Dossier 7: Proximité et environnement. https://doi.org/10.4000/developpementdurable.2666.

Tomé HG. 2019. ¿Qué innovaciones sociales para la gestión participativa e integrada del agua en Río Salado, Puebla (México)? Análisis de la gestión integrada del agua de una subcuenca. Repositorio de Tesis. Universidad Laval, Quebec, CanadáTomé H G, Villarreal M LA. 2022. Caracterización morfométrica de la cuenca del río Huitzilac, Puebla, México. Boletín geográfico 44 (1): 41−58. https://dialnet.unirioja.es/servlet/articulo?codigo=8523565.

Vargas U G. 2005. La experiencia del Estado de Michoacán en la Gestión Integral de Cuencas: El Caso de la Cuenca del Lago de Pátzcuaro. *In*: Problemas socioambientales y experiencias organizativas en las cuencas de México. Vargas S, Mollard E. (eds); Instituto Mexicano de Tecnología del Agua/ Institut de Recherche pour le Développement: Jiutepec, Morelos; Mexico, D.F; México; pp: 83–102.

Vargas VS, Mollard E. 2005. Problemas socioambientales y experiencias organizativas en las cuencas de México. Jiutepec, Morelos. IRD-IMTA. 386 p. https://agua.org.mx/wp-content/uploads/2007/06/Problemas-Socio-Ambientales-y-Experiencias-Organizativas-en-las-Cuencas-de-Mexico.pdf.

WHO (World Health Organization). 2003. Right to Water. Health and human rights publication series Num. 3. Water, Sanitation and Health Team. 43 p. https://apps.who.int/iris/handle/10665/42661.