ISSN 0188-6266
doi: 10.15174/au.2016.1070
ACTA UNIVERSITARIA
Multidisciplinary Scientific Journal

Multilevel governance for local management of drinking water in Latin America: case studies from Costa Rica, Honduras and Mexico

Gobernanza de múltiple escala para la gestión local del agua de consumo humano en América Latina: estudios de caso en Costa Rica, Honduras y México

Fernando Gumeta-Gómez*, Elvira Durán*, David B. Bray**

ABSTRACT

Adequate supply of drinking water at local level depends, in many cases on community participation. We compare three governance regimes for drinking water management based on multilevel collective action: 1) *ASADAS* in Costa Rica, 2) *Water Boards* (JAA, for its acronym in spanish) in Honduras and 3) *Water User Committees* (CA, for its acronym in spanish) in Mexico. Our data is based on participant observation, and formal and informal interviews. Legal framework, structure and operation, and efficiency for provision and conservation of water resources are analyzed. *ASADAS* and *Water Boards* are legal entities with recognized community participation and collective action, while *Water Committees* have no legal support by the Mexican Government. Regimens showed similar structures and operation, but different economic capabilities and efficiencies in the provision of water and in ensuring water recharge. Recognition and empowerment of the *Water Committees* in Mexico could increase and ensure water provision in the long- term.

RESUMEN

El abastecimiento del agua para consumo humano a escala local puede depender de la participación social. Se compararon tres regímenes de gobernanza para gestión del agua basado en acción colectiva y en entidades anidadas: 1) Asociaciones Administradoras de Sistemas de Acueductos y Alcantarillados Sanitario (ASADAS) en Costa Rica, 2) Juntas Administradoras del Agua (JAA) en Honduras y 3) Comités de Agua (CA) en Oaxaca, México. Se analizaron el marco legal, la estructura y operatividad y la eficiencia en la provisión y conservación de los recursos hídricos mediante revisión documental, observación participativa y entrevistas informales. ASADAS y JAA son reconocidas legalmente, mientras que los CA no tienen soporte en el marco legal mexicano. Los regímenes mostraron estructuras y operatividad análoga, así como tendencias similares hacia eficiencia en la provisión del agua y en asegurar la recarga hídrica, pero capacidades económicas diferentes. Reconocer y empoderar los CA en México podría aumentar y garantizar el abastecimiento de agua a el largo plazo.

Recibido: 27 de octubre de 2015
Aceptado: 31 de mayo de 2016

Keywords:
Water supply; local governance; water committees; Oaxaca; sustainability of water.

Palabras clave:
Abasto del agua; gobernanza local; comités del agua; Oaxaca; sustentabilidad del agua.

Cómo citar:
Gumeta-Gómez, F., Durán, E., & Bray, D. B. (2016). Multilevel governance for local management of drinking water in Latin America: case studies from Costa Rica, Honduras and Mexico. *Acta Universitaria*, *26*(NE-3), 3-13. doi: 10.15174/au.2016.1070

INTRODUCTION

In 2010, rights to water and sanitation were recognized as essential for all humanity. Nevertheless, these rights are not always fulfilled due to variables such as heterogeneous availability of fresh water, overexploitation, pollution, inadequate regulation and management of water and human rights violations (United Nations Educational, Scientific and Cultural Organization-World Water Assessment Programme [UNESCO-WWAP], 2006; Organización de las Naciones Unidas [ONU], 2010). It has been suggested that insufficient provision, even when there is potential availability of the resource, is result of a crisis in governance of water (UNESCO-WWAP, 2006).

* Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Instituto Politécnico Nacional (CIIDIR-IPN), unidad Oaxaca. Hornos no. 1003, Col. Noche Buena, Santa Cruz Xoxocotlán, Oaxaca, Mexico, C.P. 71230. E-mail: fernandgu3@gmail.com; eduran3@hotmail.com
** Department of Earth and Environment at Florida International University, Miami, FL, USA, 33174. E-mail: brayd@fiu.edu

ISSN 0188-6266

Governance is defined as the set of rules or institutions that constitute mechanisms for decision making for the management of a "common property resource" (Ostrom, 2011). For many decades, governance regimes for water provision have been hierarchical, where interactions between users and managers (generally a governmental institution) were top-down (Ostrom, 2008; Pahl-Wostl, 2007). Top-down regimes have multiple faults, including corruption and lack of accountability, politicization of provision, partial provision, and poor water quality (Castro, Kloster & Torregrosa, 2004; Knipier, Holtz, Kastens & Pahl-Wostl, 2010; Zurbriggen, 2011). Thus, international institutions such as the World Bank have suggested that privatization of drinking water provision is the optimal choice to ensure supply and an adequate management of the resource (Zurbriggen, 2011). This scheme is based on an economic model for management regulated by private companies. Private enterprise would mediate water provision between providers and final users, following again a top-down model (Castro *et al.*, 2004). Privatization of drinking water supply is a risk, especially for marginal sectors such as rural communities, since it could result in exclusion and inequality that could exacerbate social marginalization (Dwinell & Olivera, 2014).

Community participation and collective action has been widely emphasized as a strategy to improve water governance over provide mechanisms of conflict resolution (Ostrom, 2011; Pahl-Wostl *et al.*, 2007). Participation allows empowerment of communities and consolidation of non-hierarchical and decentralized social governance regimes (Ostrom, 2011; Zurbriggen, 2011). These regimes have proved viable at local scale for providing services and goods while reducing inequality and exclusion (Madrigal, Alpízar & Schlüter, 2011; Ruiz & Gentes, 2008). Social governance regimes favor horizontal interactions, trust and empathy between different stakeholders (Jessop, 1998). Although they are not panaceas, these regimes can be more efficient for resource management, and can be linked with formal institutions at various levels, as multilevel governance regimes (Pahl-Wostl *et al.*, 2007).

Multilevel governance for drinking water requires collaboration of government agencies, communities, non-governmental organizations (NGOs), and the private sector in the decision-making process, which can ensure an efficient management with the final goal of water provision to all users (Termeer, Dewulf & Van Lieshout, 2010). It also includes planning, fund raising, infrastructure building, regulation, administration (Rivas-Tobar, 2009), and collective choice about access and appropriation of water (Lautzen, De Silva, Giordano & Sanford, 2011; Pahl-Wostl, Holtz, Kastens & Knieper, 2010).

Climate change scenarios suggest a lower availability of water that will make local-level planning linked to multiple level governance regimes more essential. This is true for both agriculture (Meinzen-Dick, 2007; Robson & Lichtenstein, 2013; Verzijl & Domínguez, 2015), and drinking water. Some examples of effective community governance regimes come from Latin America, *e.g.* Costa Rica (Madrigal *et al.*, 2011), Honduras (Bray, 2015), Nicaragua, Bolivia and Mexico (Guerrero-De León *et al.*, 2010). These cases represent an opportunity to compare legal framework, structure and operation, and efficiency for water provision and conservation of water resources at local level of different governance regimes. The goal of the present work is to analyze and to compare three case studies for drinking water management in Latin America (Costa Rica, Honduras and Mexico). We analyzed advantages and limitation of these local governance regimes to ensure water provision and sustainability.

MATERIALS AND METHODS

Study area

We studied multilevel governance regimes denominated as: Management Associations for Aqueduct and Sanitation Systems (ASADAS, for its acronym in spanish from Costa Rica, all acronyms in Spanish), Water Boards (JAAs, for its acronym in spanish from Honduras) and Water User Committees (CAs, for its acronym in spanish from Mexico) (figure 1). Water recharge at the study sites takes place in watersheds covered by tropical forest in Costa Rica and Honduras, and a combination of subtropical and tropical forest in Mexico. Case studies were selected opportunistically (George & Bennett, 2005) based on access to the experiences by the authors and similarities in governance regimes. Direct observations and documentary evidence were available for all cases.

Four ASADAS were studied in the Cartago Provincial in Costa Rica (El Mora, La Flor, Pavones and Tres Equis), which have operated for nearly three decades (previously named Administration Committees for Rural Aqueducts [CAARS, for its acronym in spanish] until 1997). Water supply comes mainly from springs concessioned by Ministry of Environment and Energy (MINAE). Water is directed to collecting tanks and then distributed through a hydraulic network to some 1500 registered users. For Honduras, we analyzed the case of 27 JAAs that belong

to Water Administration Boards of Southern Sector of Pico Bonito National Park (AJAASSPIB), Municipality of Olanchito, Department of Atlantida. Four communities are within Pico Bonito Park and 23 are in the buffer zone with provision for all of them coming from the 14 micro-watersheds in the park. JAAs have existed for decades, but their effectiveness in drinking water provision at the local level was more fully realized after Hurricane Mitch (1998), when AJAASSPIB was created (Bray, 2015). Water from the upper watershed in the 14 micro-watersheds is directed to tanks, followed by distribution through pipes to varying numbers of communities in each watershed. In the 27 communities a total of 1713 families are thus being supplied with drinking water. In Mexico, we studied seven CAs located in Cuilapam de Guerrero, Jalapa del Valle, San Martin Tilcajete and Santa Catarina Minas, all of them in the Atoyac River watershed in Oaxaca. CAs have been in operation for nearly five decades. Wells located by riverbanks are the main source for provision; some of them regulated by the National Water Commission (Conagua, for its acronym in spanish). Springs are the source of water in Jalapa del Valle case. In all cases, water provision follows the same scheme previously described for distribution and covers demand from hundreds to as many as 1400 users in each CA.

Data collection in the field and literature review

We collected qualitative information from the available literature, informal interviews and participant observation. Legal framework behind each governance regime (ASADAS, JAAs and CAs) in each of the three countries was analyzed. Literature review includes peer-reviewed papers, theses, and gray literature. We also reviewed internal documentation (rules and assembly) in the case of *CAs* in Mexico.

We followed Ostrom's eight "design principles" of stable common pool resources (clearly defined boundaries, clear rules regarding appropriation and provision of common resources, collective-choice arrangements, effective monitoring, graduated sanctions, mechanisms for conflict resolution, self-determination of the community, multi-level and nested organization) to design a semi-structured interview to be applied to stakeholders from three countries (Ostrom, 1990). We conducted informal interviews to compare structure and operation of various governance regimes for provision and conservation of water resources. Interviews included: 1) Leaders and representatives of four ASADAS and CAs. 2) Authorities of government institutions responsible for management of water resources, e.g. Instituto Costarricense de Acueductos y Alcantarillados (ICAA), the MINAE and *Corredor Biológico Volcán Central Talamanca* (CBVCT) in Costa Rica; and Conagua authorities in Oaxaca and its municipalities where CAs are functioning. 3) Professionals on community participation for water provision in Costa Rica, Ecological Development Fund in Honduras, Rodolfo Morales Foundation in Mexico, and the private sector representatives in Oaxaca.

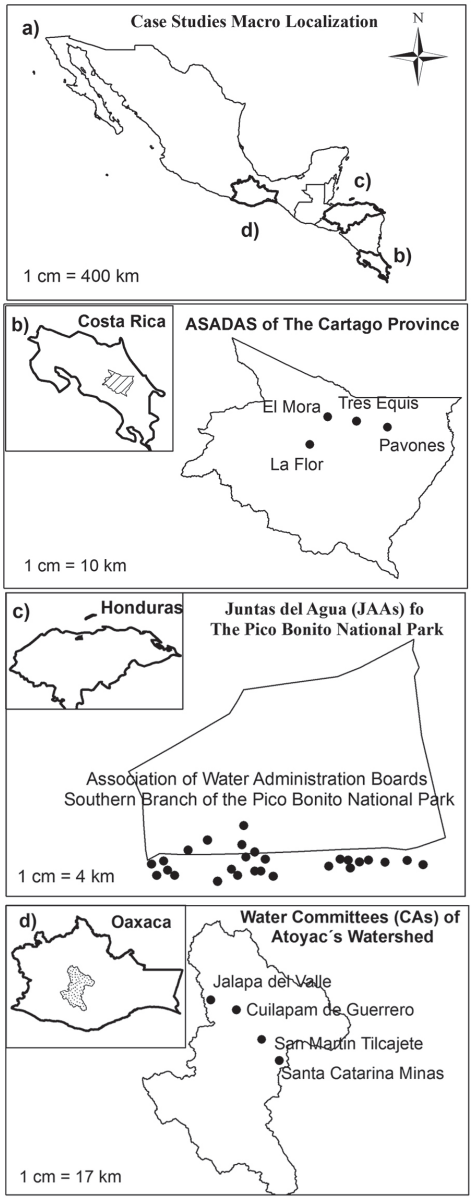

Figure 1. Macro and micro localization of the three cases of study: *a*) Localization of the countries in Latin America, *b*) ASADAS in Costa Rica, *c*) Location of the 27 JAAs in Honduras, and *d*) CAs in Oaxaca, Mexico.
Source: Author's own elaboration.

ISSN 0188-6266

Additionally, we conducted participant observation on all study cases (Puri, 2011) to document hydraulic network construction, and maintenance, and monitoring from springs and wells. We conducted site visits to analyze state of water recharge areas; and observed reforestation activities in Honduras and Mexico. In the case of Oaxaca, we observed payments collection, service closures for delayed payment users, and decision-making meetings.

All information from interviews and field observations was digitalized and systematized for analyses and comparisons between regimes. Information was cross-referenced between users for validation (Bernard, 2005). Water provision efficiency was analyzed by determining percentage of unpaid volume, payments towards cost of the hydraulic network, and users with regular service, as suggested by González, Bensusan, Estrada & Rocha (2012). Conservation of water resources was evaluated by considering restoration and conservation actions at water recharge areas, such as land purchasing at upper water basins, reforestation, wall building for water and land retention, and environmental education regarding water and forest services.

RESULTS

The legal framework

Governance regimes for water management have a legal framework with official recognition for ASADAS in Costa Rica and JAAs in Honduras case. Their role for water provision, mainly in rural and sub rural areas has been fully recognized. CAs in Mexico have no legal recognition under current legislation (table 1).

Table 1.
Legal framework for management and governance of water provision at different administrative levels for three study cases in Latin America.

Scale	Costa Rica	Honduras	Mexico
Law	Water Law 1942	Water's General Law 2009 + Drinking Water and Sanitation Legal Framework, 2003	National Water Legislation 2004 (updated in 2014)
National Institution	----[3]	*Secretaría de Recursos Naturales y Ambiente*	*Secretaría del Medio Ambiente y Recursos Naturales (Semarnat)*
No Centralized institution[1]	*Instituto de Acueductos y Alcantarillados* (AyA) *Ministerio de Ambiente y Energía* (Minae)	*Comisión Nacional de Agua y Saneamiento* (Conasa; *Órgano Consultivo*) *Servicio Autónomo Nacional de Acueductos y Alcantarillados* (SAANA; Operational institution) *Ente Regulador de Servicios de Agua Potable y Saneamiento* (ERSAPS; management institution)	*Comisión Nacional del Agua* (Conagua)
Regional	*Dirección Regional del* AyA	*Consejos de Cuenca* (Management board) *Agencias Regionales de la Autoridad del Agua* (Operational institution)	*Consejos Regionales de Cuencas* *Dirección Regional de Conagua*
State level	---	*Consejos de Subcuenca*	*Organismos Operadores* (O.O) State level
Municipality (local[2])	O. O. Municipalities Private sector CAARS ASADAS	*Consejos de Microcuencas* O. O. *del Municipio* Private sector *Juntas Administradoras de Agua*	O. O. Municipality Private sector (*Comités del Agua*[4])

[1] All belong to the same legal entity, but have some independence for decision-making and operation; [2] Municipality is responsible for water provision in the three countries. Nevertheless, there may be other institutions involved in water management depending on the country; [3] Costa Rica has no one institution responsible for water management; it is legally administered by more than 20 government entities (Aguilar *et al*., 2004); [4] Water User Committees have existed for more than five decades but haven´t been considered under current Mexican legislation.
Source: Author's own elaboration.

Legal framework in Costa Rica was established in 1942, including decentralization of water management at different scales and with a multi-institutional scheme for adequate management of this resource. At local scale, municipalities are responsible for water provision, but current legislation also provides for participation of private sector (especially for San Jose City) and communities in the form of the CAARS and ASADAS (a more regulated type of CAARS). Costa Rica government has promoted conversion of CAARS into ASADAS, which has resulted in an increase of 611 ASADAS in 2008 to 2000 of these committees by 2015 (Madrigal *et al.*, 2011). In 2003, legal framework for Water Management and Sanitation was created in Honduras for operating at various scales. At local level, it recognizes and sets structure for the operation of JAAs, which was reinforced by the 2009 General Water Law. In Mexico, CAs have operated for many decades as local governance regimes for management of drinking water in Oaxaca. Nevertheless, 2004 National Water Legislation, modified in 2014, does not allow for local participation and in water provision and gives all responsibility to municipalities and the private sector, throughout state or municipal enterprises or in concessions.

Committees Structure and Operation

Assemblies and Decision Making

All three studied governance regimes have similar decision-making structures, where assembly of all water users is the main forum. Assemblies are composed of all users. Thus, allow for participation, dialogue and discussion to reach a consensus. User participation is variable among three cases, been ASADAS the lowest, JAAs the highest, and in CAs assistance is mandatory. Agreements for resolution of problems in water provision emerge from assemblies. Problems addressed include access and use of water, regulation of interactions between users and involved institutions, maintenance of the organization and resource, as well as hydraulic network issues, collection of payments and other contributions, fines, accountability and transparency. In addition, board representation, employee hiring, and election of support committees take place in the assembly. Finally, interactions with authorities from government agencies and other stakeholders for water provision take place in the assemblies. Periodicity of assemblies is variable. They may only take place once or twice a year, with "extraordinary" meetings held if needed, but in Mexico, CAs can meet up to three times in the same month.

Elected Officials and Implementation of Agreements

All water committees have an analogous structure in the three analyzed countries (table 2). Their basic structure includes a president, secretary and treasurer, all elected by the assembly. The president has the highest responsibilities and coordinates secretary and treasurer work. ASADAS have an additional representative, the vice-president that works in coordination with the president and takes his place when he is not available. In JAAs and CAs case there are selected substitutes, called vocales, for each of the three elected officials who provide support and stand in when they are not available. Committees assume functions for periods between 1 and 3 years, as required in legislation in Costa Rica and Honduras, and in the internal regulation of CAs in Mexico. Reelection is common in ASADAS, where some representatives have been in office up to 15 years. Elections for new committee members take place every two years in JAAs case. Salaries are not provided in Costa Rica, but "food incentives" are given in compensation. Water committees constitute the lowest level of governance regimes for drinking water management, and can establish links with government agencies institutions and implement assembly' agreements. They ensure water provision and have responsibility for planning for improvements and problem solving. In Honduras, there are meetings for JAAs and for the umbrella organization AJAASSPIB. ASADAS committees have more authority for decision making without taking into account the assembly. This is different from JAAs and CAs where decisions cannot be made with consulting with the assembly Accountability and Administration.

Water committees are responsible for management of financial resources and infrastructure in the three studied governance regimes. Nevertheless, ASADAS can delegate this responsibility by hiring an accountant and a manager who receive payments of approximately $1500 US per month. These two employees are responsible for the hydraulic network, bookkeeping, and the administration of income and expenditures, and most importantly, for reporting to the water committee. In contrast, JAAs and CAs don't have enough funds to pay this kind of employees; therefore the Secretary, an unpaid position, is responsible for coordinating finances and organizing all paper work from meetings, regulations, and any other documentation related to water management, while the treasurer is responsible for bookkeeping (payments, general income and expenditure).

ISSN 0188-6266

Table 2.
Structure of the three studied governance regimes for management of drinking water.

Structure of the governance regimes		Costa Rica	Honduras	Mexico
		ASADAS	***Water Boards***	***Water Committees***
Users Assembly		X	X	X
Water board	President	X	X	X
	Vice-president	-	X	-
	Secretary	X	X	X
	Treasurer	X	X	X
	Financial Assistant	X	X	-
	Vocales	-	X	X
Employees	Administrator	X	X*	-
	Accountant	X	-	-
	Plumber	X	-	X
	Pumper	-	-	X
Support Committees	Maintenance and Operation Committee	-	X	-
	Micro-watershed committee	-	X	-
	Sanitation and Environmental Education Committee	-	X	-
	Works committee	-	-	X
	Health committee	-	-	X

* Only at the *AJAASSPPB*, and not present at the *JAAs* Level.
Source: Modified from Gumeta-Gómez, Durán & Bray (2015).

Users' payments fund governance regimes but there are differences in how activities are funded. ASADAS and JAAs can get subsidies, financial support and donations from government programs and NGOs, due to their legal status. JAAs have low income and cannot pay for a sophisticated hydraulic network; therefore, their networks are very basic. Nonetheless, they have been able to gather enough money from user's contributions to purchase land in the upper water basins to ensure water recharge and stream flow. CAs have also income from users' payments, but additional support come from fines for being absent from assemblies, water misuse, late payments (ranging from $7 to $70 US), as well as in-kind participation in communal work. In addition, the federal government (Conagua) or municipalities provide some occasional funds to pay electricity, infrastructure or employees.

Rates for service were variable between the three governance regimes. ICAA in Costa Rica establishes rates at the national level for all ASADAS based on used volume (~US $4.40 to US $15). JAAs and CAs have no set payments. For example rates are low (~US $ 0.50 a US $ 2) and charged monthly but increase depending on consumption, as stated by the JAAs representative don Carlos Cruz: -"if someone uses more, then pays more"-. In CAs regimes, payment is variable and determined at the assembly; it ranges from ~US $2.50 to US $25.

All three regimes have similar accountability processes in the form of reports once or twice a year to the assembly, including a final report at the end of the elected period. In addition, ASADAS officials need to present a financial report to the ICAA. Even though there is no supervision of JAAs and CAs finances by the government, social participation is enough to ensure accountability of financial resources. In CAs case, lack of accountability or misuse of funds results in sanctions to committee members, which prevents future corruption attempts. Sanctions include repayment of missing funds or no access to water services at their homes for life.

Hydraulic network maintenance

ASADAS and CAs have some hired staff "the *fontanero* or *bombero*", respectively, to check, fix leaks, provide maintenance to the hydraulic network, control water provision to different sectors, and turn on and off pumps (the last action only at the CAs). Committees pay

these two employees; in CAs case it is the only paid position. Sometimes, part time plumbers are hired when more specialized work is required. Nevertheless, salaries differ between ASADAS and CAs, in the first case salary ranges between US $800 and US $1000 per month, and payment is in the range of ~US $200 and US $260 for the same amount of work at the CAs. There are not hired employees at the JAAs, but work is voluntary as a community service by the Support Committee for Operation and Maintenance. This latter committee is not present in the ASADAS, and their activities are variable between JAAs and CAs.

Multi-scale governance

Costa Rican legal framework allows for the association of ASADAS into confederations (groups of ASADAS) and federations (groups of confederations). JAAs can conform associations, such as the AJAASSPIB, which groups a total of 27 JAAs. This is not the case of the CAs; many leaders have no knowledge regarding the existence of other CAs. Possibility of association of ASADAS and JAAs gives them institutional presence, allowing them to access internal microcredits and external financial support. The first regime has a strong connection with the Minister for the Environment and Energy (MINAE) in Costa Rica that helps with creation of confederations, supervises water quality and concessions of springs, and in conflict resolution around inappropriate land use. ASADAS also have a close link to ICAAs, institutions that help ASADAS to obtain their legal status, which also requires an annual financial report, provides water quality certificates, training and financial support for hydraulic network expenses. Health Ministry is another important ally for certifying water quality, providing training, and supplements for water purification.

JAAs have no clear connection to government institutions, but their collaboration with US-based NGO Ecologic Development Fund is source of support. This group has provided JAAs with training, fund raising, and support to strengthen the umbrella organization AJAASSPIB. Some CAs have collaborations with some formal local institutions such as *Comisariados de Bienes Comunales* or *Ejidales* (authorities responsible for communal land tenure). This link is necessary when infrastructure, restoration of hydraulic network and reforestation is needed. Most CAs request funds from the municipality for infrastructure or electricity, even though they are independent institutions. Another important link in Mexico is Conagua that supervises water extraction from wells and renews their concession to CAs when necessary.

Efficiency for the provision and conservation of water resources

Governance regimes registered water provision efficiencies between 95% and 100% (table 3). Collective action has allowed building and maintenance of basic hydraulic infrastructure that ensures a nearly total provision of drinking water to locals. Water is filtered-chloride for all the cases studied, since it does not meet all the physical and chemical requirements of potable water. Other general indices to measure efficiency on water provision are low percentage of water leaks (5% to 10%) and the high levels of payments by users (90% to 100%).

Table 3.
Comparison of three governance regimes for provision and management of drinking water in Latin America.

Indices	Costa Rica	Honduras	Mexico
National water provision (%)	100 urban[1] 89 rural	97 urban[2] 78 rural	95 urban[3] 77 rural
Water provision by studied governance regimes (%)	99	~100	95
Percentage of unpaid water under the National provision system	50[1]	46[2]	44[3]
Percentage of unpaid water under the studied governance regimes	5	Not available	10
Paid bills by users	100%	100%	90%
Reforestation of water recharge areas	Yes	Yes	Yes
Purchase of land for water recharge	Yes	Yes	Not needed when communal areas (ejidos) include the upper part of the basins
Water retention works	No	Yes	Yes
Soil retention works	No	Not clear but there is reforestation activity	Sometimes
Environmental education related to water and forest	No	Yes	No

Source: Joint Monitoring Programe (JMP) World Health Organization (WHO)/ United Nations Children's Fund (UNICEF) (2014) for [1] Costa Rica; [2] Honduras; [3] Mexico. The rest of the information was compiled during the present work.

ISSN 0188-6266

All committees have implemented various efforts to ensuring water recharge. ASADAS together with the MINAE in Costa Rica are responsible for preserving vegetation coverage at springs by legal establishment of a protected area around the springs, 100 m under the Water Law and 200 m in the Forestry Legislation. ASADAS look for support for purchasing land where springs are located to ensure their conservation. JAAs have been able to create an environmental fund with contributions by users' payments, the municipality and NGOs. The final goal of this fund is the purchase, restoration and conservation of forest in the upper section of the micro-watershed, where springs are located. They have established nurseries and create dams for water retention. Another benefit for JAAs are payments that AJAASSPIB makes for every planted tree (US $1). CAs in Oaxaca pay close attention to conditions and threats to upper watershed that provides water to wells used by them. They work in close collaboration with the Comisariado de Bienes Comunales and the municipality in reforestation. CAs has not always promoted the infrastructure for water and soil retention. Nevertheless, assemblies discuss actions for water retention at rivers and wells, in addition to working to prevent sedimentation. JAAs are the only regime conducting environmental education for younger generations.

DISCUSSION

It is suggested that no panaceas exist in relation to water management institutions (Meinzen-Dick, 2007). However, governance regimes for drinking water management based on multilevel collective action are promising institutional schemes. Even though they are heterogeneous, there are examples of effective functioning with respect to social, economic and environmental dimensions. These regimes are not only efficient in ensuring provision, but also are very effective at building and maintaining the hydraulic network, accountability and address some of the sustainability aspects of water management.

Legal framework

Governance regimes emerged in different contexts and some of them have functioned for various decades as collective action institutions to solve provision and appropriation of the water resources (Bray, 2015; Gumeta-Gómez *et al.*, 2015). A main difference between the case studies is the lack of legal recognition of CAs in Mexico that may be a threat to their future continuity (Ostrom, 2011). This situation jeopardizes adequate supply of water that CAs provide to rural areas, since the Mexican state has failed to achieve full coverage (Torregrosa, 2013). At the same time, without the legal recognition of CAs, government agencies can't establish clear rules on self-management and monitoring of a resource of public interest such as water, and voiding "grabbing" for the sake of a few as documented in Jalisco (Guerrero-De Leon *et al.*, 2010).

In 2004, the General Law for Water Management, modified in 2014, still does not recognize *CAs* and gives responsibility for water provision only to the municipalities and state officials. A recent proposal to modify this legal framework is mainly designed to benefit management of water resources by private sector and reduction of users' rights. These actions aim to privatize water supplies, which means that service charges will have to be high enough to cover all the costs of investment in infrastructure and maintenance as well as profits. With privatization, companies have little supervision by government, which can cause high levels of corruption and may result in an exacerbation of poverty and social inequity, as in Bolivia (Dwinell & Olivera, 2014). In addition, with the legal clause of *causas de utilidad pública*, community involvement and participation for the defense of water for local use will be limited.

ASADAS and JAAs have a major advantage because their legal status clearly sets their rights and obligations, which allows them to access other sources of funding, e.g. NGOs, private companies and government funds, to provide maintenance and improve infrastructure for drinking water provision. This benefit could be also available for CAs if they get legal recognition. However, income from users' payments and varying agreements with municipalities and other government institutions have been enough to cover the operational cost and for maintenance of the hydraulic network. Another benefit of ASADAS and JAAs legal status is their access to technical support and training by government in Costa Rica and Honduras, or by NGOs. In CAs case, leaders have learned most of the knowledge regarding water management in practice and have passed this technical information on to increase community collective knowledge. Chaves (2014) documented some ASADAS case from the Cartago province in Costa Rica where technical assistance and capabilities were a key factor for ASADAS success regarding water provision.

Operability and Structure

Structure of the three governance regimes for drinking water management was very similar. The most important differences were in the committees functioning as how tasks and their attributions were conducted.

ASADAS governance regimes have more leeway for decision-making by leadership, reducing transaction costs in facing contingencies. However, this can have a negative impact on user involvement resulting in more top-down approaches to dealing with problems and participation in maintenance (Madrigal *et al.*, 2011). Leadership in JAAS and CAs is not as strong, and decisions are presented to users' assembly, promoting involvement and local participation, which is considered a key factor for water provision at local systems. All the above-mentioned actions require time but are important for the appropriation of water as a resource (Marks & Davis, 2012). Users at CAs have set very rigid rules and graduated monetary sanctions to people who miss meetings or collective work. Ostrom (2011) mentioned that the establishment of graduated sanctions, as in CAs from Oaxaca, is one of the necessary principles to maintain collective action, to prevent "free-riding" and water shortages as a Common Pool Resource (CPR).

In Costa Rica not all ASADAS have financial or infrastructure capacity (Madrigal *et al.*, 2011). Nevertheless, analyzed ASADAS in the present work had stronger financial capabilities than JAAs and CAs regimes, being able to hire administrators, accountants and plumbers on a permanent basis. JAAs and CAs, used committee members to perform those duties; even though they did not have training, previous experience or even completed their basic education (primary school) in the extreme cases.

Multilevel Governance

ASADAS, JAAs and CAs have the necessary characteristics to be defined as multilevel governance regimes (Ostrom, 2011). All three interact with government institutions and NGOs at different scales. This is a characteristic necessary to ensure long-term existence of self-organized governance systems (Ostrom, 2011) and for their success in facing all the challenges of climate change on water systems (Brondizio, Ostrom, & Young, 2009). Strong collaborations with local institutions allowed implementation of conservation and restoration actions at watershed upper sections in CAs' case. However, Mexico is adopting a model where private companies and municipalities are responsible for drinking water provision, with limited social participation (not all users are represented and the selected representative has voice but no vote) only at the Watershed Boards (*Consejos Regionales de Cuencas*). Thus, there is little or no opportunity to participate in decisions at regional or national level (Perevochtchikova & Arellano-Monterrosas, 2008), since social participation is only symbolic.

Efficiency for provision and conservation

Water provision efficiency was evaluated by the number of households that have the service, which was higher than the national average in all three governance regimes. Leaks, considered as unpaid water, were well under the average reported at national level. We cannot make generalizations about efficiency of ASADAS, JAAs, and CAs, but them showed high potential for a more effective way of water provision.

For example, comparing CAs at Ocotlán, Oaxaca, with a nearby municipality showed that the latter was not efficient in water provision and maintenance of hydraulic network. Additional problems included politicization regarding distribution and a reduced income from users payments (less than 30%), which resulted in a higher demand of State subsidies or federal funds (González *et al.*, 2012). Similar examples can be found in peripheral city areas where citizens demand access to water (Peña, 2005). Nevertheless, there is also a risk associated with *CA*s control over access to water at local level, if they do not have an holistic vision for micro-watersheds management, as in the case of Jalisco (Guerrero-De León *et al.*, 2010). Management of water resources should not focus only on efficient provision, sustainability goals must be set also (Meffe, Nielsen, Knight & Schenborn, 2002).

All three governance regimes analyzed by the present work have been able to achieve water provision in rural areas with sustainability goals, including the creation of collective knowledge of users regarding the need to preserve forest as a recharge area (Hamilton, 2009). Don Carlos Cruz from the AJAAS-SPB expressed this: "with our work, we aim that the springs and wells that we use today will continue to produce good quality water for the following 50 years or even more". Our analyzed governance regimes conduct multilevel collective actions for conservation and restoration of recharge areas, either at upper watersheds or around springs. CAs conduct reforestation efforts and build water retention infrastructure, even though they are not legally recognized or sometimes have no property rights over recharge areas. Water treatment was the major limitation in the studied regimes, since none of them invests in this activity. Nevertheless, communities are aware that problems in water quality should not be passed on to other areas. For example, CAs rejected a municipality project because no treatment plant was considered and the final destination was the river.

ISSN 0188-6266

Climate change has been recognized as a major threat for water provision, reducing availability and quality of water resources (Bates, Kundzewicz, Wu & Palutikof, 2008). Our cases studied showed a long-term vision regarding management of water, representing viable options to be taken into account by public policies mitigation and adaptation strategies for water provision and recharge of aquifers (Iglesias, Garrote, Flores & Moneo, 2007).

CONCLUSIONS

Governance regimes are efficient in water provision in rural areas of Costa Rica, Honduras and Mexico, areas that have the lowest priority and attention from the governments. Organization, cooperation and agreements reached by ASADAS, JAAs and CAs' users showed high levels of self-regulation and compatibility with social, economic and environmental conditions at local level. Even in Mexico, were CAs have not been legally recognized, this governance regime has demonstrated its capacity for self-determination and multilevel collaboration with government institutions, allowing them to provide water to many rural communities in Oaxaca. The studied governance regimes are result of varying social, cultural and historical processes. But have been present for various decades and their long-term vision may help them to continue into the future, supplying and regulating water and carrying out local collective action for the maintenance of water recharge. We highlight importance for CAs recognition under the Mexican legal framework, which will allow them to access financial support, training and professional assistance, but most important to share their experience with similar regimes. It is necessary to promote public policy that recognizes and strengthens social participation in water governance at regional level, which is a widespread occurrence in Mexico, but until now has been little documented. Participatory governance regimes for water management have social capital to face challenges of variation in water resources due to climate change, and may also be key for mitigating its impact at local scale.

ACKNOWLEDGEMENTS

The lead author thanks *Consejo Nacional de Ciencia y Tecnología* (Conacyt) and *Beca de Estímulo Institucional de Formación de Investigadores-Instituto Politécnico Nacional* (BEIFI-IPN) scholarship programs for support to conduct the present work and a research internship at the CATIE, Costa Rica. We thank *Instituto Politécnico Nacional* for SIP- 20140771, SIP-20150962 and SIP-20161084 grants. We are especially thankful to the Ecologic Development Fund for the opportunity to collaborate on the Honduras case study. We thank Gustavo Hinojosa-Arango for his help in the translation for first version. We also thank for the two anonymous reviewers of this manuscript for their valuable comments.

REFERENCES

Aguilar, S. A., Alvarado, Z. X., Astorga, E. Y., Avendaño, M. S., Blanco, O. C., Mora-Portuguez, J., Rodríguez, V. G., Rodríguez, R. H., Vartanián, A. D. y Zeledón, J. M. (2004). *Hacia una Nueva Ley del Agua*. *Memoria de un proceso de construcción participativa*. Grupo Tecnico del Agua. San Jose, Costa Rica.

Bates, B., Kundzewicz, Z., Wu, S., & Palutikof, J. (2008). *Climate Change and Water. Technical Paper VI of the Intergovernmental Panel on Climate Change*. Geneva: IPCC Secretariat.

Bernard, H. R. (2005). *Research methods in anthropology: qualitative and quantitative approaches* (4th edition). Oxford, U.K.: Altamira Press.

Bray, D. B. (2015). *Facing Future Storms: Poor Honduran Communities Unite to Protect Watersheds and Nature*. Retrieved from http://news.mongabay.com/2015/0505-bray-honduran-community-conservation.html

Brondizio, E. S., Ostrom, E., & Young, O. R. (2009). Connectivity and the governance of multilevel socio-ecological systems: The role of social capital. *Annual review of environment and resources*, 34, 253-78.

Castro, J. E., Kloster, K., & Torregrosa, M. L. (2004). Ciudadanía y gobernabilidad en México: el caso de la conflictividad y la participación social en torno a la gestión del agua. En B. Jiménez & L. Marín, *El agua en México vista desde la Academia* (pp. 339-369). México: Academia Mexicana de Ciencias.

Chaves Soto, G. (2014). *Propuesta y validación metodológica con enfoque de resiliencia para el análisis de las dinámicas socioecológicas de sistemas de abastecimientos de agua para consumo humano* (tesis de Maestría en Ciencias). Centro Agronómico Tropical de Investigación y Enseñanza, Escuela de Posgrado: Turrialba, Costa Rica.

Dwinell, A., & Olivera, M. (2014). The water is ours Damn it! Water commoning in Bolivia. *Community Development Journal*, *49*(1), 44-52.

George, A. L., & Bennett, A. (2005). *Case Studies and Theory Development in The Social Sciences*. Cambridge, MA.: MIT Press.

González, V. F., Bensusan, N. R., Estrada, D. C., & Rocha, D. G. (2012). Diagnóstico de los servicios de agua y saneamiento en tres municipios representativos del estado de Oaxaca. *XXII Congreso Nacional de Hidraúlic*a, Acapulco, Guerrero.

Guerrero-De León, A., Gerritsen, P. R., Martínez-Rivera, L. M., Salcido-Rulz, S., Meza-Rodríguez, D., & Bustos-Santana, H. R. (2010). Gobernanza y participación social en la gestión del agua en la microcuenca El Cangrejo, en el municipio de Autlán de Navarro, Jalisco. *Economía, Sociedad y Territorio*, *10*(33), 541-567.

Gumeta-Gómez, F., Durán, M., & Bray, D. (2015). La participación social en la gobernanza y gestión local del agua para uso doméstico en America Latina. En *Memoria del Seminario Iberoamericano de Redes de Agua y Drenaje*. XIV SEREA. Guanajuato, México.

Hamilton, L. (2009). *Los bosques y el agua*. Roma, Italia: Organización de las Naciones Unidas para la Agricultura y la Alimentación, Estudio FAO: Montes 155.

Iglesias, A., Garrote, L., Flores, F., & Moneo, M. (2007). Challenges to manage the risk of water scarcity and climate change in the Mediterranean. *Water Resources Management*, *21*(5), 775-788.

Jessop, B. (1998). The rise of governance and the risks of failure: the case of economic development. *International Social Science Journal*, *50*(155), 29-45.

Joint Monitoring Programe (JMP) World Health Organization (WHO) / United Nations Children's Fund (UNICEF) (2014). *Estimates on the use of water sources and sanitation facilities. Costa Rica, Honduras y Mexico*. Retrieved Abril, 20 2015 from http://www.wssinfo.org/documents/?tx_displaycontroller[type]=country_files

Knipier, C., Holtz, G., Kastens, B., & Pahl-Wostl, C. (2010). Analyzing water governance in heterogeneous case studies-Experiences with a database approach. *Enviromental Science and Policy*, *13*(7), 592-603.

Lautzen, J., De Silva, S., Giordano, M., & Sanford, L. (2011). Putting the cart before the horse: Water governance and IWRM. *Natural Resources Forum*, *35*(1), 1-8.

Madrigal, R., Alpízar, F., & Schlüter, A. (2011). Determinants of performance of community-based drinking water organizations. *World Development*, *39*(9), 1663-1675.

Marks, S. J., & Davis, J. (2012). Does user participation lead to sense of ownership for rural water systems? Evidence from Kenya. *World Development*, *40*(8), 1569-1576.

Meffe, G. K., Nielsen, L. A., Knight, R. L., & Schenborn, D. A. (2002). *Ecosystem Management. Adaptative, Community-Based Conservation*. Washington, Covelo and London: Island Press.

Meinzen-Dick, R. (2007). Beyond panaceas in water institutions. *Procedings of the National Academy of Science of the USA*, *104*(39), 15200-15205.

Organización de las Naciones Unidas (ONU) (2010). *Resolución A/64/L.63/Rev.1. El derecho humano al agua y saneamiento*. US: Organización de las Naciones Unidas.

Ostrom, E. (1990). *Governing the commons: the evolution of institution for collective action* (2da. ed.) Cambridge, UK: Cambridge University Press.

Ostrom, E. (2008). Institutions and the environment. *Economic affairs*, *28*(3), 24-31.

Ostrom, E. (2011). *El gobierno de los bienes comunes. Evolución de las instituciones de acción colectiva* (2da edición). México: Fondo de Cultura Económica / Instituto de Investigaciones Sociales-Universidad Nacional Autónoma de México (UNAM IIS).

Pahl-Wostl, C. (2007). Transition towards adaptive management of water facing climate and global change. *Water resources management*, *21*(1), 49-62.

Pahl-Wostl, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D., & Taillieu, T. (2007). Social learning and water resources management. *Ecology and Society*, *12*(2), 5. Retrieved from http://www.ecologyandsociety.org/vol12/iss2/art5/

Pahl-Wostl, C., Holtz, G., Kastens, B., & Knieper, C. (2010). Analyzing complex water governance regimes: the management and transition framework. *Environmental Science & Policy*, *13*(7), 571-581.

Peña, F. (2005). La lucha por el agua. Reflexiones para México y América Latina. En *Pueblos indígenas, estado y democracia* (pp. 217-238). Buenos Aires, Argentina: Consejo Latinoamericano de Ciencias Sociales (CLACSO).

Perevochtchikova, M., & Arellano-Monterrosas, J. L. (2008). Gestión de cuencas hidrográficas: experiencias y desafíos en México y Rusia. *Revista Latinoamericana de Recursos Naturales*, *4*(3), 313-325.

Puri, R. K. (2011). Participant observation. En H. Newing, *Conducting research in conservation: A social science perspective* (376 pp.). London and New York: Routledge.

Rivas-Tobar, L. A. (2009). *Efectos de la teoría de la complejidad en la gestión ambiental en México*. México: Instituto Politécnico Nacional / Centro Mario Molina.

Robson , J. P., & Lichtenstein, G. (2013). Current Trends in Latin American Commons Research. *Journal of Latin American Geography*, *12*(1), 5-31.

Ruiz, S. A., & Gentes, I. G. (2008). Retos y perspectivas de la gobernanza del agua y gestión integral de los recursos hídricos en Bolivia. *European Review of Latin American and Caribbean Studies*, 85, 41-59.

Termeer, C., Dewulf, A., & Van Lieshout, M. (2010). Disentangling scale approaches in governance research: comparing monocentric, multilevel, and adaptive governance. *Ecology and Society*, *15*(4), 29.

Torregrosa, M. (2013). El agua en México. *Conversus*, (104), 6-7.

United Nations Educational, Scientific and Cultural Organization-World Water Assessment Programme (UNESCO-WWAP) (2006). *The 2nd United Nations World Water Development Report: Water, a shared responsibility*'. Oxford, UK.: United Nations - World Water Assessment Programme.

Verzijl, A., & Domínguez, C. (2015). The powers of water-user associations: on multiplicity, fluidity, and durability in the Peruvian Andes. *International Journal of the Commons, 9*(1), 107-128.

Zurbriggen, C. (2011). Gobernanza: una mirada desde América Latina. *Perfiles Latinoamericanos, 19*(38), 39-64.