The functionality of the socio-technical components of community-managed water in Andean rural communities in Bolivia

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This work was supported by the VLIR-UOS Programme

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Abstract

This study aimed to analyse the association between the functionality of community water organisations (CWO) and different aspects related to community-based water management (CBWM) such as the supply source, the system functionality, financial sustainability of service and sustainable management practices. Household interviews were collected in 35 rural communities in Pucarani, Bolivia. Results show that a functioning CWO was associated with accessing to piped water; having sufficient water; being affiliated to the CWO; saving water practices along with the community and having water during the dry season. It was also negatively associated with the continuity of the service.

Keywords: Community management organisations; Community-based organization; Rural; Functioning; Bolivia

1. Introduction

Over the last decade, progress has been made to provide safe drinking water to people throughout the world. In 2015, the proportion of the population using safely managed drinking water services increased from 76 per cent in 1990 to 91percent (1). In Latin America and the Caribbean, this proportion reached 95 per cent (2). Despite this progress, in the region, about 21 of the 33 million people without access to safe drinking water live in rural areas (2). In Bolivia, although 90 per cent of the population had access to an improved water source in 2015 (3), the proportions were 72 per cent for those in rural areas and 95 for those in urban areas (4).

With the emergence of the Sustainable Development Goal Number 6 (SDG-6), the emphasis is being given to more efficient management of water to address the increasing frequency of droughts and floods as a result of climate change. It also calls for actors to support and strengthen the participation of local communities in water management improvement (5).

In most of the low and middle-income countries, Community Based Water-Management (CBWM) is the accepted model for rural water supply (6, 7). It is also a strategy for operationalising its mainstream participatory development in the rural area (8, 9). However, it is being argued that under this model, development players (international donors, NGOs, and governments) dismiss the responsibility for maintenance and sustainability once the water system infrastructures are installed. Therefore, communities are charged with ensuring the water operation, usually through water committees and local level water organizations(6). These are usually non-profit organizations, made up of the inhabitants of a concentrated rural community, whose objective is to supply safe drinking water to its members, assuring the continuity of water service and its affordability (10).

In consequence, there is a growing concern about the high failure rates of newly installed water points within the first few years of construction, and about the capacity of communities to implement CBWM(6, 11). There is also an increasing debate about the need for support from external agencies to water community organisations (7, 9, 12). Many examples of succeeding CBWM have been reported, often related to functioning community-managed water organisations and the professional or technical support they receive (7, 13).

The sustainability and maintenance of the water systems are usually attributed to two interconnected dominions; the physical infrastructure of the system and the local management capacity to install, operate and maintain the infrastructure. Both together are referred to as the "socio-technical interphase" (6, 14, 15).

Besides, the concept of 'functionality' has appeared in the current development efforts to provide a safe water supply. Nonetheless, within the CBWM approach, it is not only the functionality of the physical infrastructure (the pumps and pipes) that is of concern but also the functionality of the Community Water Organizations (CWO) that manages it(6). Some evidence suggests that the functionality of the infrastructure is often expected to be dependent on the functionality of the CWO. Hence, significant efforts are directed towards identifying ways in which CWO could be strengthened (6) There is a rising understanding of the importance of community-based water for the sustainability of rural water supplies. Nonetheless, there is little quantitative evidence and a very limited understanding of socio-technical interactions.

The Bolivian government is committed to the implementation of an Integrated Water Resources Management (IWRM) policy, considering the river basins as units for water management and governance (16). However, evidence shows that local water spaces are flexible and strongly related to local organisations; while the river basin concept is applied by water professionals,

taking the dimension of this space sometimes in abstract terms. Thus, there is an existing relationship between local water management and communal territories. Therefore, river basin spaces and its governance overlap with existing water management and communal territories. Therefore, the physical infrastructure of water supply systems are constantly interacting with community water organizations, and face resistance to the implementation of the IWRM (17).

Furthermore, despite the existence of the IWRM policies that include the social and customary norms, as well as community participation during the planning and implementation of the water system infrastructure, the designers pay little attention to accomplishing these aspects (18). Consequently, multiple projects have effects that go beyond the duplication of efforts and economic expenditure, but also, as, in other low-middle income countries, this might be associated to low sustainability and consequences related to poor quality of life of people and community development (7).

It is recognized that CWO have a long tradition in Bolivia. Research, mainly qualitative, in rural and peri-urban areas has been conducted to understand how these CWO organise themselves (19); how external support should be provided to CWO(20); how the paradigm of the IWRM policy conforms the reality of local Water Management spaces (17), and how the interaction between CWO with other actors of the water sectors is.(21)

This study is focused in the Pucarani Municipality which belongs to the Andean region of Bolivia. According to its authorities and local informants, the water systems built by the Government and Non-Governmental Organizations (NGO's) (22), lack enough maintenance and has operational problems(23).

The purpose of this study The aim of this study was to analyze the association between the functionality of community water organizations (CWO) and different aspects related to

community-based water management (CBWM) such as the supply source, the system functionality, financial sustainability of service and sustainable management practices. As far as is known, this is the first study to examine the socio-technical functionality of community-managed water in rural Bolivia. The results will provide information to policymakers to improve sustainable access to safe drinking water.

2. Methods

*2.1.*Study area and sampling

Pucarani is the capital of Pucarani Municipality, the first municipal section of the Los Andes Province in La Paz, Bolivia. It is divided into three areas (North, Central and South) which in turn is divided into more than 100 communities with 28.465 inhabitants (24).

The sample was selected using a two-stage cluster random sampling methodology. In the first stage of the two-stage randomised cluster sampling, 35 communities were selected and the sample size was obtained at 3% error margin and a 99% confidence interval. A total of 1022 households were sampled. In the second stage, random routes were used with stated rules for selecting households.

*2.2.*Design, study population and data collection

This is a cross-sectional study based on data collected by face to face interviews, conducted with the heads of the selected households (men or women) or any other member over 18 years of age.

The questionnaire included five sections on water supply sources, characteristics of the water system operation, the functionality of the community water organisation, water users' payment of service fee, and community participation in sustainable water management practices. Responses

to questions were dichotomous and multiple-choice formats. The content validation of the questionnaire was performed by several experts reviews and through pilot testing.

2.3. Ethical considerations

A consent form described the general and specific information about the study. Researchers respected the right to privacy, confidentiality. Freedom to withdraw from the study at anytime was ensured.

2.4. Variables

The dependent variables were the components of community-based water management: water supply sources; characteristics of the water system operation, financial sustainability of water service, and community participation in sustainable water management practices. Table 1 shows the descriptive response categories. For regression analysis, indicators of socio-technical functionality in each item were selected and the resultant variables were dichotomised (Tables 2 to 5).

The independent variable was the degree of functionality of the Water Community Organization (CWO). This variable was measured through the following indicators related to the respondents' perception about CWO: a) respondent's knowledge about the existence of the CWO in the community; b) respondent's perception of the CWO performance; c) the existence of a person(s) in charge of the system maintenance in the community; and d) if respondent's turn to CWO in case of problems with the water distribution system. Based on these proxy indicators, the independent variable "CWO functionality" was created. The categories were established as: 0 = non–existent (the absence of these indicators); 1 = developing functionality (the presence of 1 or 2 indicators); 2 = high functionality (the presence of 3 or 4 indicators).

2.5. Data Analysis

First, descriptive statistics analysis of the CBWM components were conducted. In addition, an associative bivariate analysis was carried out using the Chi-square test ($p \leq 0.5$) to determine differences between CWO functionality and each one of the dependent variables. Finally, robust Poisson regression models were fitted to obtain prevalence ratios (PR; IC95%) and quantify these associations. The analysis was segregated by sectors in Pucarani: North, Centre, and South. Data management procedures were conducted using SPSS 24.0. (IBM, Armonk, NY, USA).

3. Results

Out of the study population, 58% (n=595) were women, the mean age (standard deviation) was 49 years (±17.39) and 42% (n=427), were men, the mean age was 49 years (±17.17).

Table 1 shows the distribution of the study variables segregated by sectors of Pucarani. It was evidenced that most of the population used two main sources of water: through pipe (77.1%) and well (47.9%); being the northern sector the one that had larger distribution through pipe (84.4%), having a difference of 10 percentage points (pp.) in relation to the other sectors.

Regarding the water system operation, about 37.2% reported not to have sufficient water supply and it is the southern sector that was affected the most by lack of water (42.6%). Only 48.6%) of the population had water service for the 24 hours of the day; the northern sector had the most water service continuity (57.3%) and the southern sector presented most problems with 12.2% getting water service every other day. About 60% wasn't satisfied with the service provided, especially in the southern sector where 65% was unsatisfied with it.

Most of the respondents did not perceive conflicts regarding water (63.2%). However, people in the central sector perceived them mostly (41.0%). The main cause of water conflict was lack of

water (21.0%) and water withholding by the people in charge of the community water management (11.9%).

With respect to the financial sustainability of water service, only 61.3% of the population was charged for water service and the southern sector is the one that was charged the least (52.5%) with a difference of 10 pp compared to other sectors. Besides, only half of the participants (49.2%) paid for the service, being the southern sectors where the least amount of payment was registered (38.2%).

Respecting to community participation in sustainable water management, under 20% of the participants reported being shareholders of the Water Community Organization (CWO), being the southern sector the one with least affiliation (12.8%). Water-saving as a habit at home was practised by 37.8%, and the north reported the most water-saving (41.7%). In addition, the southern sector was the one with the most rainwater collection (49.0%). Moreover, only 25.8% of the participants reported saving water practices along with the community.

The perception about the CWO showed that only a little over half of the respondents (51.6%) knew about this organisation in their community, and it was the southern sector where it was least known (44.6%). Only 10.7% of the participants perceived that the CWO had an adequate performance, while the rest thought it should be improved or didn't answer. Only 60% identified the person(s) in charge of water service maintenance and only 38% turn to him (them) when they had problems with the system.

Tables 2 to 5 show the results of the analysis of associations between the functionality of the CWO and the dependent variables. The developing and high functioning of CWO was associated with having piped water in all sectors of Pucarani (Table 2).

Besides, the developing functioning (PR:1.3; IC:1.1-1.8) and the high functioning (PR:1.7; IC:1.3-2.3) were related to the perception of water sufficiency in the north sector. Also, both levels of CWO functioning, the developing (PR: 0.5; IC: 0.4-0.6) and high functionality (PR0.3; 0.2-0.5) were negatively associated with the continuity of service in the central sector. High functioning was associated with being satisfied with the water service in the central (PR:1.8; CI:1.2-2.8) and southern sectors (PR:1.8; IC:1.2-2.7). Lastly, the developing functioning (PR: 1.4; CI:1.2-1.7) and the high functioning (PR:1.3; CI:1.1-1.7) were associated to having water in drought season in the central sector (Table 3).

The developing and high functionality of CWO was associated with the charges for water service in all sectors. Besides, the high functioning was associated with service payment in the northern (PR:1.3; IC:1.1-1.7) and southern sectors (PR:1.6; 1.2-2.5) (Table 4).

The high functionality was also associated with affiliation to the organisation in the central (PR:9.6; IC: 3.0-30.1) and southern sectors (PR:4.2; IC:1.4-12.5). At the same time, both the developing (PR: 2.4; IC: 1.2-5.0) and high functioning (PR:4.4; IC: 2.2-8.8) were associated with saving water practices along with the community.

4. Discussion

This study aimed to describe the functionality of community water organisations (CWO) in Pucarani. Also, to analyse its association with different aspects related to community water management such as the water supply source, the water system functionality, perceptions about the community water organisation, financial sustainability of water service, and sustainable water management practices.

This study found that a functioning CWO was associated with a higher probability of having access to piped water and also to the perception of having sufficient water in all of the sectors of

Pucarani. This result can be explained by the fact that obtaining access to piped water, its maintenance and the water system operation in the community are the responsibilities of the CWO. A previous study conducted in Bolivia, Peru and Ghana, found that when water supply programmes include a community management model (CBM) a working piped water system is evidenced, even in the long term after its installation (10, 25)

At the same time, regarding the operation of the water systems, there was a negative association between a functioning CWO and the continuity of the water service provided in the central sector. A plausible explanation for this result is the saving water practices implemented in this sector. As shown in the descriptive results, this sector has a higher number of saving water practices in the community; it also has a higher probability of having water during the dry season. Thus, the discontinuity of the service might be part of preventive water distribution and a saving strategy taken by the CWO. Previous research on CBM showed the need also for improving community engagement and participation in sustainable water management in all of the phases, especially in the long term (7, 26).

Concerning the financial sustainability of the water system, the results show that a functioning CWO is associated with charges collection to water users in all sectors of Pucarani. It is also associated with the service payment in the northern and southern sectors. This result coincides with previous studies that show that one function of the CWO is the definition of financial bookkeeping and a pre-set time table(6). This is crucial for generating the collective decision to meet payments (27), and the ability to raise funds (15).

Besides, when a CWO does not have enough resources to perform adequately, the poorly understanding of the shareholders about the importance of paying for sustainable water service is evidenced (6). However, the evidence suggests that rather than over-focusing on the regularity

of payments, more attention should be paid to the contingencies of rural people's livelihoods. For instance, to ensure the payments, it has been suggested that CWO should collect charges at periods closely linked to the rhythms of the seasonal calendar, considering agrarian cycles of production(28, 29).

Furthermore, the collection of non- monetary resources have been proposed as a manner of employing mobilisation mechanisms by water committees. Thus, community members can exchange monetary resources for time, labour, and other forms of capital, which also contribute to the sustainability of the system (30).

Finally, regarding community participation, this study found that functioning CWO were associated with affiliation to these organizations in the central and southern sectors, they were also related to saving water practices in the central sector. It is known that in the community-based management (CBM) model, CWO must be vehicles to empower communities through affiliation and participation of its members, and at the same time, promote a better and equal distribution of the resource use (31). Furthermore, the literature shows that the roles of CWO are also related to the sustainability of water resources. To do this, CWO perform a series of regular activities including meetings, collection and saving water practices (7).

Based on the study results and their consistency with previous evidence, it can be said that a functioning CWO is associated with key components of effective community-based water management, although the patterns of these relationships vary according to the sectors of Pucarani and with the degree of functionality of the CWO itself.

Besides, there is a common assumption that physical components (technology, infrastructure, landscape) and the social (community management, cultural norms and practices) are ‘co-constituted’(32). For instance, the infrastructure needs to work – to be functional – while at the

same time, it also reflects the functionality of the community management. There is also a mutable nature of water supplies, as they need to be adaptable to different contexts and environments to be sustainable, as well as the community water organisations (6). Thus, relevant socio-technical analyses of water show that infrastructure and the social component are inherently political, enabling or constraining technical, managerial and socio-political elements of water control (Bolding et al., 1995). Thus, water management power relations and might infuse local water governance arrangements, mediating patterns of access and use resulting in a dynamic processes (6, 7, 33), and differences in among communities.

Therefore, as the functioning of CWO organizations is associated with the maintenance, operation and sustainability of water systems, more reflection should be made on the conditions in which members of the CWO perform their functions, usually in adverse circumstances. This also led to pose new questions about the roles of the CWO capacity to perform these roles in the long term(6, 34-36).

Crucial factors associated with the functioning and sustainability of CWO has been recognized as widespread. For instance, it is known that CWO based on voluntarism and informality does not guarantee the sustainability of the initial enthusiasm of their members to participate. Likewise, other authors have identified the importance of the "sense of ownership" of the water system, that provides CWO with the power and responsibility of management (6, 34-36).

Also, a recent study in the urban and peri-urban areas of Cochabamba, Bolivia, showed that internal factors of CWO, such as leadership, agreed on vision, collective action and management are associated to three distinct planning and management phases and were found to be of major importance for community-managed water and wastewater systems (19)

In addition, based on a previous qualitative study conducted in Pucarani, it is not that CWO perform their tasks with little support, with minor coordination with local authorities, and the need for technical and management support is evident. These aspects might affect the sustainability of water systems supply in Pucarani.

In fact, worldwide evidence suggest that the CBWM model could be improved through a) a more effective supporting role of the local authorities to CWO; b) having the external support to improve the management and technical skills of the CWO members and of the community, since it is the source of potential members of the CWO (6, 34). These aspects are the main aims of the CBWM "plus" model.

In a study in Bolivia, Ghana and Peru, Whittington et al. (2009) show that the majority of CWO receive some external support. However, communities mostly solicit and receive this in an ad hoc manner, if and when the need arises and in response to specific problems (13). However, usually the external technical support from NGOs focuses on training (monitoring, conflict resolution, identifying maintenance needs) and awareness-raising, and less on empowering users to craft their solutions (12).

Strengths and Limitations

To our knowledge, this is the first study that analyses the association between the socio-technical interphase of community-based water management.

A limitation of the study is its cross-sectional design, which precludes causal interpretations. However, the associations found have been consistent with previous findings. Another limitation is that the use of proxy indicators to analyse the degree of functionality of the CWO. However, this study had an explorative aim and was not limited to a predetermined set of parameters.

Conclusions

In all sectors of Pucarani, a functioning CWO was associated with accessing to piped water and having sufficient water. In the Central sector, it was associated with saving practices along with the community, having water during the dry season and negatively associated with the continuity of the service. In the south, it was associated with being affiliated to the CWO.

Future research is needed to understand better the interactions between the socio-technical interphase of CBWM, and if possible identifying factors that lead to good performance and sustainable water systems, especially those related to the CBWM model "plus" such as the specific demands for external support from local governments and external agencies.

Conflict of interest

The authors declare no conflict of interest.

Funding Details

This work was supported by the VLIR-UOS Programme

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