Institutional determinants of performance of drinking water community organizations in rural areas of Costa Rica: A comparative case studies analysis.

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To be presented in WoW 4, Indiana University

Working paper, do not cite or quote. Comments are very welcome

Abstract: This paper presents an institutional analysis of the underlying factors affecting the performance of drinking water community organizations in rural areas of Costa Rica. These organizations provide water to more than 25% of total population in the country; however, there is a high disparity in their performance. This research tries to understand how a complex configuration of physical characteristics of watersheds and infrastructure, governance system and socio-economic attributes of users affects different dimensions of performance in rural communities. Using a qualitative approach and matching techniques to ensure comparability, the paper analyzes four communities in depth to understand what factors and causal mechanisms influence financial and physical performance as well as user satisfaction. The main results highlight the relevance of a demand-driven approach coupled with downward accountability; effective rules for tariff collection and infrastructure maintenance and appropriate support from the government as the main conditions that promote higher levels of performance.

Key words: Institutional Analysis and Development Framework (IAD), Social Ecological Systems (SESs), propensity score matching.

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We have received important inputs for research design and field methods from Armando Razo, Elinor Ostrom, Juan Robalino, María Claudia López and Xavier Basurto. We also thank Carla A. Flores for her valuable support in data collection and processing. All errors and omissions remain full responsibility of the authors.
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1. INTRODUCTION

Access to safe drinking water and sanitation is a global concern to meet the Millenium Development Goals, and in recent years has been increasingly addressed as a basic human right of nations (UNDP 2006; UN 2007). However, in most rural areas of the developing world, drinking water coverage from an improved source and sanitation services remain unacceptably low (WHO and UNICEF 2006). Despite the importance of these issues in the political agenda, water policies in many countries do not promote the creation of appropriate institutions for managing water needs and, enhancing supply augmentation and management capabilities (Saleth and Dinar 2004).

Specifically for the case of water, over the past 50 years, a series of institutional arrangements, ranging from strong governmental participation to decentralized arrangements, has been promoted as panaceas to improve water management. However, each of these approaches has failed as a blueprint strategy or policy prescription, largely because the variability of local situations and the difficulty of transplanting institutions from one context to another (Meizen-Dick 2007).

Even though Costa Rica has one of the highest coverage ratios for drinking water in rural areas in Latin America (WHO and UNICEF 2008), the disparities between urban and rural sector in access of drinking water persist. The provision of drinking water by different types of community organizations in rural areas is widespread in Costa Rica, in contrast to the prevalence of governmental water utilities in urban areas. Unfortunately, some of the water community organizations leave consumers exposed to poor water quality, and in the long run their poor organizational and financial performance further jeopardizes the future provision of potable water.

The current organizational structure of drinking water sector in rural areas of Costa Rica constitutes an interesting setting to analyze how different institutional arrangements generate alternative incentives that ultimately affect the sustainability of resource use as well as the benefits people perceived. Despite the relevance of the issue and given the higher disparity of performance in rural water community organizations, there is no systematic evaluation about the circumstances in which some organizations have performed well while others not. Furthermore, given that central government has historically subsidized this sector and recently promoted a transformation in the legal status of these

organizations, it is important to understand how the incentives generated by these policies might affect performance.

Using a comparison of carefully selected cases and a qualitative approach, we present an institutional analysis that aims to shed light on the causal mechanisms that explain why some communities succeed, or failed, to solve collective action problems related to drinking water provision. In particular, our main goal is to understand how effective rules, mediated by biophysical characteristics and community attributes, produce different patterns of interactions that lead to differences in performance. Furthermore, an adequate assessment of the potential and effectiveness of local organizations is necessary to avoid policy prescriptions that fail to capture the particular socio-ecological interactions present in every watershed.

This paper is organized as follows. The next section describes the general characteristics of drinking water sector in rural areas of Costa Rica. In Section 3 we present our theoretical framework and briefly discuss the principal results of the literature of determinants of performance in water community organizations. In Section 4 we present our research design, including case selection strategy and collecting data protocols. The last two sections present our results and conclusions, respectively.

2. DESCRIPTION OF WATER SECTOR IN COSTA RICA

Historically, the Costa Rican government has assumed a direct role in the conservation of natural resources and the provision of basic services to the population, including drinking water. The ICAA (Instituto Costarricense de Acueductos y Alcantarillados, by its spanish acronym) is an entity constituted in 1961 by the central government with the dual purpose to oversight drinking water use throughout the country, and to be responsible for the design, construction and, management of infrastructure to provide drinking water to urban and rural communities (ICAA 2007). From the 1960´s to the 1990's there was a governmental boom in the construction of infrastructure for providing drinking water, but in some cases, the administration was delegated from ICAA to local communities. The funds for the construction and maintenance of this infrastructure mainly came from governmental budget and international loans.

In rural areas, besides ICAA´s administered systems, there are two different types of community-based organizations: CAARs (Comités Administradores de Acueductos Rurales) and ASADAS (Asociaciones Administradoras de Sistemas de Acueductos y Alcantarillados Sanitarios). There are more than one thousand CAARs and ASADAS, responsible for the provision of water to nearly one million people. The main difference between both community-based organizations is that ASADAS have a formal delegation agreement with ICAA. In recent years, ICAA is actively promoting the transformation of CAARs into ASADAS with the aim of strengthening its legal status and hence, its performance. However, from the theoretical point of view and from an empirical perspective, there is no guarantee that this policy blueprint will be an effective set of rules to ensure an adequate provision of water in rural areas.

The delegation agreement implies the transfer of authority for public functions (water withdrawal and management rights) to local organizations outside the central government but ultimately, these organizations are formally accountable to the central government. This uniform agreement includes 22 formal responsibilities that every ASADAS must fulfill, no matter its location or its size. Table 1 presents some of the main characteristics of these organizations.

Table 1. General statistics of principal water providers in rural areas

	CAAR	ASADAS	Rural ICAA
Number of organizations	434	658	33
Media (population served)	821	997	12.447
St.dev. from media	1,073	1,219	14.633
Median (population served)	430	546	8.148
% Potable*	51	58	N.A
% Gravity Systems	47	51	N.A

N.A. Not available
* Based on microbiological criteria
Source: Own calculations based on ICAA 2007, ICAA 2008, LNA 2008

Besides the necessity to increase the potability of water provided to users, there are other challenges for rural water community organizations in Costa Rica (ICAA-OPS-OMS 2002). Some of these problems are: i. To the greatest extent, revenues do not allow full cost recovery; this leads to underinvestment in the sector. In the case of ICAA, there are cross-subsidies from the metropolitan area of San José to the rural areas; ii. Poor organizational and operational practices; iii. Approximately 50% of rural infrastructure is in regular to poor condition.

3. THEORETICAL FRAMEWORK

Adequate infrastructure is fundamental to provide sufficiently potable water for daily needs in rural communities. However, the provision of water under conditions of reliability and quality do not depend exclusively on engineering solutions related to infrastructure. The hydrogeological and hydrographical characteristics of watersheds as well as human decisions on land use, especially in recharge areas are also relevant because they have a direct impact on the water needed to feed this infrastructure. Furthermore, the incentives that individuals and groups might have to devise rules to access, allocate and consume water affect its supply, and hence, in a recursive manner, generate a new pattern of incentives to utilize the services provided by ecosystems.

Broadly speaking, the interactions between humans and ecosystems are described in the literature as social-ecological systems (SESs) (Anderies et al. 2004). In this paper we are adapting the multitier framework for analyzing SESs developed by Ostrom (2007), and further developed by Meinzen-Dick (2007). This conceptual map enables us to organize highest-tier variables that could affect the patterns of interactions and outcomes observed in particular SESs, such as water provision in rural areas. At its broadest level, this theoretical framework analyzes how resource system characteristics, the resource units generated by that system, the attributes of the users of that system and the governance system jointly "affect and are indirectly affected by interactions and resulting outcomes achieved at a particular time and place" (Ostrom 2007). These variables and outcomes "may affect and be affected by the larger socioeconomic, political and ecological setting in which they are embedded, as well as smaller ones" (Ostrom 2007).

Table 2 presents the conceptual framework for first and second tier variables. For empirical analysis and data collection, we decomposed the broadest level variables into third and fourth tiers whenever more detailed and specific variables were necessary[4].

[4] A detailed list of variables at lower tier levels is on Appendix A.

Table 2. First and second tier variables in framework for analyzing rural drinking water organizations

SOCIAL, ECONOMIC AND POLITICAL SETTINGS (S) S1: Economic development; S2: Demographic trends; S3: Government water policies; S4: Market incentives	
RESOURCE SYSTEM (RS) RS1: Clarity of system boundaries RS2: Infrastructure characteristics RS3: Location RS4: Scarcity: relative water supply (stock) RS5: Predictability of system dynamics RS6: Type of water source RS7: Watershed characteristics	**GOVERNANCE SYSTEM (GS)** GS1: Type of organization GS2: Accountability GS3: Network structure GS4: Property rights system GS5: Operational rules GS6: Collective-choice rules GS7: Constitutional rules
RESOURCE UNITS (RU) RU1: Growth or water replacement rate RU2: Spatial and temporal distribution of water	**USERS (U)** U1: Number of beneficiaries U2: Socioeconomic attributes U3: History of use U4: Human capital U5: Social capital
INTERACTIONS (I) → OUTCOMES (O)	
I1: Demand-driven approach I2: Motivational problems I3: Information sharing	O1: Physical performance O2: Consumer satisfaction O3: Financial performance
RELATED ECOSYSTEMS (ECO) ECO1: Pollution patterns. ECO2: Flows into and out of focal SES	

Adapted from Ostrom (2007) and Meinzen-Dick (2007)

Many conceptual tiers used in the analysis came from a literature review of determinants of performance or sustainability of rural drinking water community organizations[5] (Isham and Kähkönen 2002; Kähkönen 1999; Sara and Katz 1998; Watson et al. 1997; Stalker 2005; Stalker et al. 2008). In particular, these studies have highlighted the relevance of a demand driven approach as primarily determinant of good performance. This approach, that includes community participation on design and willingness to pay, seems to be more effective where levels of social capital are relatively high before infrastructure construction (Kähkönen 1999; Narayan 1995).

The SESs framework enables to use different theoretical tools to explain processes that lead to different outcomes. Our work relies heavily on public goods and common-pool resources theory to

[5] Because provision problems for drinking water are similar to those faced by farmers in irrigation systems; we are relying also on the well-known literature of institutional determinants of performance in these systems (Araral 2006; Lam 1998; Ostrom 1990; Shivakoti and Ostrom 2002, Vermillion 1997).

understand the appropriate incentives needed to overcome collective action problems[6]. Drinking water provision in rural communities has an intrinsic motivational problem due to the non-excludability nature of the resource system. That leads to situations in which users have a strong incentive to free-ride on others effort to provide the service. This motivational problem, derived from the characteristics of the physical world, exacerbates in situations where rules are non-existent or not enforceable to reduce the temptation to free-ride on others.

The tendency to free-ride could be seen at two different levels. First, communities as a whole might have incentives to rely on governmental budget or external donors. Infrastructure constructed with donor assistance is a classic case of Samaritan´s Dilemma (Gibson et al.2005). In these cases the recipient of help knows that the external donor (the Samaritan) will help them, no matter their level of effort. The structure of incentives leads to a situation where the recipient gives little effort and relies on external help. Second, within the community, there are members that might to free-ride on others pecuniary and non-pecuniary contributions. In extreme cases, this pattern of incentives leads to underproduction of the good (Olson 1968).

On the other side, principal-agent theory is also useful to explain some of our particular puzzles. In this regard, some scholars (Gibson et al. 2005; Araral 2006) highlight the informational problems that arise when the provision of particular public good or common-pool resource requires the construction and maintenance of infrastructure over time. Furthermore, some perverse incentives that foster dependence might be in place when donors finance the short-term provision of public goods without a realistic plan of maintenance and without an adequate sense of ownership on the part of the recipient (Gibson et al. 2005; Ostrom et al. 1993). The concept of ownership is inherently related to the existence of property rights or some kind of enforceable authority to undertake particular actions (Commons 1968, cited by Agrawal and Ostrom 2001). Differences in property rights might generate diverse incentives for solving collective action problems related to water provision. Furthermore, the complexity of the resource system and units requires the definition of different property rights for land

[6] NEED TO ADD SOME REFERENCES HERE

and water. In this sense it is useful to distinguish a bundle of property rights related to access, withdrawal, management, exclusion and alienation (Schlager and Ostrom 1992).

Performance evaluation implies the verification of achievement of certain objectives. However, there is no scholarly agreement regarding what objectives must be considered as well as the methods to measure these outcomes in water community organizations[7]. Based on a literature review of the performance measures that have been evaluated in recent years in this sector (that includes Narayan 1995; Sara and Katz 1998; Gross and van Wijk-Sijbesma 2001; Stalker 2005; Thorsten 2007; Stalker et al. 2008), we have concluded that there is an implicit agreement that performance is a multidimensional concept that includes financial aspects, consumer satisfaction, water quality and availability, among others. However, there is almost no theoretical justification about the reasons to select one dimension or another[8]. The approaches to measure peformance are also diverse, ranging from one single indicator per dimension to indexes based on predefined scales or indexes constructed using factor analysis. Most of the literature analyzes each dimension separately; only in one case the authors combine different dimensions of performance into one single overall indicator.

4. METHODS

4.1. Research strategy

The literature of common-pool resources and collective action is mostly built around single case studies and meta-analysis thereof. However, efforts to compare case studies to obtain more general conclusions have been hindered by sample selection problems in the construction of comparative databases, disciplinary differences, missing variables, differences in conceptualization and empirical measurement of variables (Poteete and Ostrom 2008; Agrawal 2001). In this regard, our research focuses on building a set of comparable cases for qualitative analysis while maintaining some of the advantages of case studies reported in the literature, for example: i. the capacity to generate new hypothesis rather than testing existing ones, ii. the opportunity to study causal pathways instead of

[7] The process of benchmarking and performance evaluation of water utilities in urban areas of Latin America has been extensively developed in recent years (Corton 2003; Berg and Lin 2007; Berg and Corton 2007; Berg 2008). However, given the relevance of rural water community organizations in the region, there is a surprisingly lack of studies that tries to measure performance in this sector.

[8] A similar problem has been reported by Lam (1998) in the literature related to performance in irrigation systems.

measuring the causal effect on selected variables on outcomes, iii. the possibility to conduct in depth and detailed analysis of selected cases (Seawright and Gerring 2008; Gerring 2007; George and Bennett 2005; Flyvbjerg 2006).

The aim of our case selection strategy is to have a collection of some representative water community organizations that differ in terms of outcomes but are similar in terms of some observable characteristics such as biophysical characteristics of location, size, age and feeder technology. Controlling for some characteristics will reduce the number of confounding factors in the relationship between explicative variables and outcomes. Furthermore, this strategy will allow us to better understand how differences in effective rules and group attributes, mediated by a particular set of control variables affect performance. In this regard, to understand why different configurations of variables lead to different results on performance, our case studies are deliberately selected on the dependent variable (i.e. performance) to guarantee sufficient variation on it. Given this, we are very cautious to over generalizing context-specific factors that explain variation on dependent variable. The evidence can only allow us to evaluate causal processes and mechanisms that explain performance.

Given the potential biases and problems associated to pragmatic selection and complete randomization for case selection, the argument for a purposive sampling that contributes to inferential process seems strong (Seawright and Gerring 2008). In this regard, there are different techniques for selecting cases depending on research objectives (Seawright and Gerring 2008, Gerring 2007). The most similar cases method will be adopted in this study because we are interested in situations where cases are similar in terms of some relevant control variables (X_1=size, biophysical characteristics, type of feeder technology, age) but differ in at least one explicative dimension (X_2=type of organization) and the outcome (Y=performance). Of course, there are some other explicative dimensions in which cases might differ but, ex-ante, they remain unobservable to the researcher in the phase of case selection and will indeed be the focus of the fieldwork.

Given our theoretical framework, there are three different dimensions of performance that can be use as dependent variables. However, we didn't have ex-ante information about these dimensions to guarantee that selected cases would have low and high levels of performance. To partially solve this

problem, we used information on water quality as a proxy for performance. By selecting on this variable we are assuring that selected cases differ at least in one important component of the physical dimension of performance. The fieldwork will complement this partial view of performance with a more comprehensive evaluation, such as the one described the section before.

As recommended in the literature (Seawright and Gerring 2008, Gerring 2007), we use matching techniques to identify similar cases from a large cross sectional data set. Matching techniques have become a very useful statistical tool to estimate treatment effects in different empirical settings (Caliendo and Kopeinig 2005, Gerring 2007). The logic behind the estimation involves pairing treatment and comparison units that are similar in terms of their observable characteristics or covariates. One particular method of matching is propensity score matching (PSM) (Caliendo and Kopeinig 2005, Dehejia and Wahba 2002).. This particular method is useful when an exact matching is unfeasible, especially in cases where the covariates are scalars, such as age, distance or when the number of matching variables is large (Seawright and Gerring 2008). In these cases, instead of looking for exact matches, the researcher tries to estimate the probability of participating in a treatment group given observed characteristics X. The description of control variables is:

- Population served: From the institutional perspective, the collective action literature have devoted a lot of attention on how group size affects the possibilities to overcome coordination problems to provide common pool resources and public goods (Agrawal 2001). This variable is also a proxy for size of the infrastructure. It is very common that water provision and sanitation exhibit economies of scale that affects efficiency (Watson et al. 1997; Valenzuela and Jouralev 2007). It is also reported that size of infrastructure has powerful impact on maintenance tasks such as repairing pipe breaks and blockages; diagnostic of problems and technological complexity (Kleemeier 2000).

- Age of infrastructure: One important component for an adequately provision of water in rural communities is infrastructure. However, the nature of the collective action problem related to the construction of infrastructure in the initial period is different to that related to maintaining the infrastructure running properly over time.

- Feeder technology system: the nature of the water source has a strong impact on the selection of the appropriate technology to convey water to the community. The type of technology employed (gravity vs pumping systems) is usually related to the general complexity of the system as well as the costs and technical skills needed to properly run the system.

- Remoteness: How remotely located is an organization could eventually affect its possibilities to develop networks with private and public organizations, including ICAA. These networks might be useful to access technical assistance and financial resources, among others. The remoteness might also affect the costs to find spare parts and perform regular procedures for the organization such as manage of bank accounts. We used to proxies for remoteness: distance from the communities to the capital city of Costa Rica and distance from rural communities to urban and semi urban areas that include facilities such as hotels, high schools and hospital or clinics.

- Climatic characteristics: The climatic and geographical conditions directly affect the difficulties for solving water provision problems in rural communities. We used information on precipitation patterns to control for climatic characteristics that might affect hydrological cycles and hence, water availability.

4.2. Data available

The data available to select cases came from three different sources: i. The official ICAA´s database on general characteristics of rural organizations such as location, population served, type of feeder technology; type of organization, among others. In some cases there are missing values for some variables because this data set is actually under construction by ICAA. ii. The official LNA (National Water Laboratory by its Spanish Acronym) data base on water quality by organization type; iii. The Digital Atlas Project of Costa Rica with GIS data on Costa Rica´s generalities as well as location of rural water organizations. We merged these data sources into one single database. Cases for which merge was impossible were eliminated. Our merged database on CAARs and ASADAS contains 1092 organizations, all over the country.

4.3. Case selection

The first decision to select cases was to focus on the Metropolitan Region, one of the seven administrative regions in which the country is divided by the ICAA. There are 72 CAARs and 104 ASADAS in this region. The reasons to select cases within this region are: i. The largest share (19%) of total population served by rural water organizations lives in the Metropolitan Region; ii. It is the second most important region in terms of number of rural water organization (16% of the nation's total); iii. Focusing on just one region allows a better control of geographical characteristics that might influence hydrological and hydrogeological patterns; iv. It ensures that all rural organizations fall administratively under the same regional team of ICAA. This is particularly important because ICAA organizes its work regionally, and some particularities of the relationship between these regional administrative units and regional local water providers might affect performance in a differentiated way.

We decided to select four cases, a high and a low performing example of each of the organizational types in the region. Our main concern was the comparability of cases and then its representativeness. The last condition was difficult to meet because there is no generalized agreement about which is the main characteristic that defines representativeness. However, in close consultation to experts we concluded that population size is the most appropriate indicator for representativeness. Having done this, to satisfy the objectives of comparability and representativeness, we applied a two-step procedure. First, we applied PSM to estimate the fitted values or propensity scores that defines the probability of each case to be assigned to the treatment group (organizational type)[9]. Second, after labelling each case with its propensity score, we reduced the population to representative cases. This was done by having a sample of cases located within a 95% confidence interval from the median population size[10]. From this representative sample, we identified the 4 cases based on its proximity to

[9] Because we had many missing values for feeder technology and age in our dataset, we ran the PSM procedure without these variables. Nevertheless, we checked after the selection of cases to verify that all cases had the same feeder technology and similar age.

[10] The population mean is 1091 people or 260 connections approximately. The population median is 567 people or 135 connections approximately.

the average propensity score of treated observations (in this case, ASADAs) and its observed performance. Table 3 includes the main characteristics of organizations selected.

Table 3
General features of organizations selected, Metropolitan Region

	CAARS		ASADAS	
	San Rafael de Arriba	**Chirraca, Los Calderón**	**Desampa-raditos**	**Bajo de Jorco**
System type	Gravity	Gravity	Gravity	Gravity
Metering	No	No	Yes	Yes
Water quality (base on microbiological tests)	Potable	Non Potable	Potable	Non Potable
Infrastructure age	26	28	28	15
Population served	435	454	840	693
Number of connections	145	108	200	165
Connection density*	22	32	36	89
Elevation (m.a.s.l.)	800	1000	800	700
Precipitation (m.m.)	3000	2500	2500	3000
Legal standing	Yes	No	Yes	Yes
Delegation agreement signed with ICAA	No	No	Yes	Yes
Social Development Index per District**	50.3	43.2	57.6	43.2
Distance to the closest regional ICAA offices (km.)	5	2	7	10

* Connections per meters of lines longitude. It was assessed ex-post.

**SDI per District compound by educational infrastructure, access to special educational programs, percentage of death from 0 to5 years on respect to general mortality, percentage of delayed population on first grade of school, monthly average household consumption on electricity, percentage of single mother baby births, canton average SDI.

4.4. Survey instrument design

To conduct in depth analysis of the causes that explain the performance of water community organizations, we designed an extensive field manual based on the theoretical framework described in the previous section. This field manual builds on a similar manual developed by The International Forestry Resources and Institutions (IFRI) to study the relationship between people and forests around the world. We kept a similar structure and data collection strategy to that of IFRI but modified the questions to fit the problem at hand based on an extensive literature review.

From the conceptual perspective, this manual is divided into five broad categories. The first is related to general questions and geospatial information. The second category is dedicated to the attributes of water community users. In this case, there are questions about socioeconomic characteristics of community, local history, social capital as well as a battery of questions to address the perception of users regarding general performance of water provision in the community. The third section is about resource system characteristics. In this section, we include questions regarding infrastructure, characteristics on recharge areas and intake points, data on availability and quality of water, among others. The fourth section is related to rules and general characteristics of the organization. In this section we seek for information on human capital of organization, financial data, social networks and property rights, among others. Finally, the last section is dedicated to constitutional rules, which includes rules and incentives coming from the ICAA and other governmental authorities.

Given the large quantity of questions and the level of detail in some of them, we used different sources of information. Some of these sources where used in a complementary fashion. The main sources are: i. direct observation; ii. content analysis of official records; iii. official databases of ICAA and LNA as well as National Census and GIS; iv. interviews to water community users; v. interviews to personnel on local water board; vi. Interviews to key informants; vii. Interviews to ICAA, and LNA.

4.5. Performance measures.

In this paper we have selected the financial, the physical and the consumer satisfaction as relevant dimensions of performance that capture some essential tasks that must be carried out in order to overcome collective actions problems in water community systems. The justification for this decision is the following. Drinking water systems are jointly uses facilities in which infrastructure must be constructed and maintained in order to provide the service. When considering the attributes of these resources, as described by Ostrom, Schroeder, and Wynne (1993), it is useful to separate service provision from service production. The first concept involves planning, financing and coordination of activities, whereas service production refers to the physical and technical action of laying water pipes and maintenance of all necessary components in the system. Both tasks are not necessarily performed by the same organization; or require the same level of coordination. Who solves these

problems and how rules are intended to overcome these challenges are crucial to understand the incentives that affect performance in a particular setting.

Given the above discussion, one of the most important activities of provision that must be coordinated is raising the necessary funds to run the system properly. For this reason, we have included a financial dimension of performance in our analysis that includes certain measurable objectives like the ability to generate a surplus after paying for O&M costs as well as tariff delinquency. The physical dimension of performance aims to capture some of the principal tasks involved in "producing" water and maintaining the infrastructure (e.g. technical evaluation of the condition of infrastructure, protection of natural areas near intake points, water quality assessments). Finally, a subjective evaluation done by users might reveal valuable information about the effectiveness of the organization to solve provision and production problems.

The description of these dimensions is included on Table 4[11]. Each dimension is evaluated by an index of different indicators that reflect the richness of data that comes from the qualitative nature of this research. It is very likely that the three dimensions selected are correlated among each other. The distinction among dimensions is more conceptually oriented rather than practical. In many cases, communities deal with provision and production problems at the same time. Furthermore, the way communities solve provision problems might affect the physical process of production and vice versa.

[11] A detailed description of the indicators might be requested to authors.

Table 4. Dimensions of performance		
Dimension	**Description**	**Indicators and source of information**
Financial	Dummy variables were included to indicate the achievement of certain financial objectives. An overall score was calculated based on individual scores per financial indicator. This overall score represents the percentage of maximum possible points obtained considering all indicators	Fee collection, cost recovery and investment self-sufficiency. Financial records of the organizations were used as main sources of information to construct the indicators.
Physical	Dummy variables were included to indicate the condition of certain physical indicators of infrastructure condition. An overall score was calculated based on individual scores. This overall score represents the percentage of maximum possible points obtained considering all indicators	25 indicators were measured in relation to spring, storage tank, conveyance infrastructure and water quality assessment. All indicators were measured on the field, based on technical criteria
User Satisfaction	This overall score results from an average of individual percentages per indicator included in this dimension.	% of households with permanent water service, % of households completely satisfied with water quantity at home, % of households that have not had any illness caused by tap water consumption, % of households with excellent perception of work done by local organization to provide water. Water users expressed their opinions in private interviews (members of the actual committee and people with direct family ties with them were excluded). 10% to 15% of houses were sampled (randomly selected) in each community.

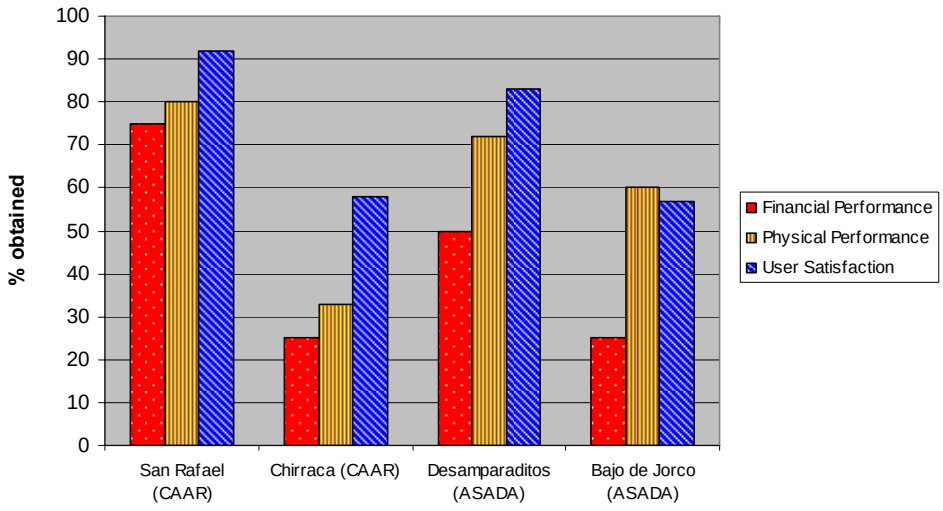
There are some caveats in our approach to performance. First, our indicators lack of a temporal dimension that allows us to track how performance could evolve over time. Second, we cannot establish the relative importance of each of the three dimensions of performance. Third, when we combine indicators into one single score per dimension, we are assuming perfect substitution among indicators. Following this line of reasoning, two communities might have an identical final score in one dimension even though they have different scores on individual indicators. Finally, it is very important

to keep in mind that our scale for measuring most indicators is ordinal, rather than a cardinal scale in which we could assess the absolute difference of performance among different organizations.

5. RESULTS

Figure 1 presents the results of the application of performance indicators described before[12].

Figure 1. Performance evaluation scores



Based on the integral evaluation of performance, San Rafael and Desamparaditos show the highest score among the four organizations. These two organizations have a very similar level of tasks achievement, despite having a different formal governance structure. The positive correlation among the three dimensions of performance is clear from Figure 1. The subjective assessment of consumers about the service provided and work done by the committee seem to reinforce the objective evaluation on financial and physical indicators. Using the theoretical framework presented in Table 2, we will discuss about the most important variables and causal relationships that explain the observed differences in performance in these organizations.

i. Resource system and resource units

The rules that aim to facilitate the coordination of decisions and the solution of collective action for water provision problems are intrinsically related to resource system and resource units characteristics. However, there are multiple differences in the infrastructure as well as watershed

[12] Authors can be contacted for a detailed explanation on calculations.

characteristics and dynamics that might affect the capacity of local communities to achieve higher levels of performance.

Land uses directly affect water quality and availability (Bruijnzeel 2004; Ilstedt et al 2007), especially in recharge areas, rivers and near springs. However, the technical complexity of defining with precision what areas of watersheds are necessary to increase water quality and availability limits the capacity of local communities to take actions on this issue. Nevertheless, in the high performing communities, local committees at least try to locally enforce the national water law that establishes the protection of 100 mts around springs and water intake points. In these areas they define and monitor rules to avoid the presence of animals, latrines and agricultural activities.

We found that an obstacle to enforce rules to keep intake points with an adequate protection was the distance from the community and the natural difficulty to access these areas. These rules are particularly important because none of the organizations chlorinates water and all water sources are superficial, increasing the vulnerability of beneficiaries to any bacteriological infection (LNA 2008).

Despite of similarities in feeder technology, age and number of lines in all systems in the sample, there are additional resource system characteristics that differ among cases and therefore, create significant differences in the complexity of the system. In particular, variations in density of connections as well as the distance from community to water intake points, affect the effectiveness and the costs of detecting failures. Given that gravity is the feeder technology in these systems, significant variations in altitude between the storage tank and the houses served, creates additional operational problems. Considering these characteristics, it is interesting to note that best performing systems tend to have relatively simple systems to operate while the low performers tend to have systems that offer more technical challenges.

ii. Governance system

The governance system that aims to coordinate all the necessary tasks to solve provision and production problems is the most important determinant of performance in the analyzed organizations.

Furthermore, although organizations might differ in their formal relationship with ICAA, their effective similarities in governance system allow them to reach similar performance levels.

Type of organization:

Historically, in some of the analyzed communities there have been different formal structures for water provision. San Rafael has had two different types of organizations: ICAA (governmental type) administration and nowadays CAAR. Desamparaditos has had three types: ICAA, CAAR and ASADAS nowadays. Bajo de Jorco has had two types: CAAR and ASADAS. Finally, there has been no formal change in the organization of Chirraca. The changes from ICAA to CAAR have been motivated by a demand driven approach while the others are mostly generated by a supply driven approach from the central government. The former transformations have generated new incentives and governance systems that positively impact performance. In the latter case, we found no evidence of significant changes in governance system characteristics that seem to impact performance. We will discuss in more detail these issues ahead.

Effective rules: There are some important collective-choice and operational rules in place that characterize high performing communities. First, at the collective-choice level there are clear responsibilities related to operation, investment and management of the system. The committee members are appointed by the community every two years and with no influence from the central government. The committee must follow a written set of rules, defined by the community. Only the community may change this set of rules. The water committee serves as a recognized and accepted arena to solve the most common problems in water provision, such as water access, water consumption, and tariff delinquency. Second, at the operational level, there is a clear set of rules in use related to financial procedures; preventive and corrective maintenance of infrastructure; and rules related to the conservation of natural areas near intake points and water quality monitoring.

In order to understand how differences in effective rules affects performance, an inventory of rules was done with the information collected in the field manual. In line with previous discussion, the two organizations with the highest score in performance, showed the highest number of rules accepted and enforced. These rules in use are mostly related to collective choice level (meetings of general

board, mechanisms to reach agreements, accountability, among others) as well as the operational level (tariffs, infrastructure maintenance, water treatment, among others). In particular, we identified 23 effective rules in San Rafael, 17 in Desamparaditos while in Chirraca and Bajo de Jorco we only identified 5 effective rules in each case[13]. Nevertheless, these conclusions must be taken with caution. First, we are not suggesting a linear relationship between performance and effective rules. We need to better understand how variations in the number and type of rules might affect performance. Second, we are not analyzing how different configurations of rules influences performance. It might be the case that different communities have the same number of rules, however, depending on the type of rules the outcomes could differ significantly.

Accountability: The delegation agreement signed by both ASADAS implies they are formally accountable to ICAA. However, we found no evidence that appropriate upwardly mechanisms for accountability were in place. Furthermore, downward accountability seems to be stronger and effective to exert pressure on committee members to include the demands of local users in decision-making processes[14]. This result seems to reinforce similar findings in which downward accountability is the most relevant element that allows the benefits of decentralization to become available to local populations (Agrawal and Ribbot 1999).

It is interesting to highlight the case of San Rafael because it shows very clearly how different mechanisms of downward accountability works. To start with, there are some formal and informal arenas in which officials can be sued. The formal arenas are constituted by ordinary assemblies held twice a year in which all people from the community could attend, ask questions and vote whenever necessary. The president and treasurer offer a public report of activities, supported by audited financial records and other relevant written documents. Every two years, in these ordinary assemblies, people have the possibility to elect new members of the committee. A formal procedure establishes that water users could remove committee members at any time.

In addition, there are some informal arenas for downward accountability. These informal arenas and related procedures are difficult to identify and measure but the interviews with water committee

[13] A detailed inventory of rules can be found in Appendix B.
[14] The list of accountability indicators used in the analysis can be found in Appendix B.

members as well as other key informants reveal some hints. There are many informal meetings that take place in many public venues. However, given that most community members live and work in the same community, it is very likely that water users can reach them very easily to request a variety of things related to water provision. Besides these public venues, most people in the community know with certainty who the members of the committee are and where their houses are located. The members of the committee have reported that it is very common that users reach them directly by phone or visit their houses to request help or to complain about general service. Given that the president and the treasurer of San Rafael are retired workers, with a high commitment to local development, dramatically increases their accessibility and their knowledge of the system.

Network structure: In this study we tried to identify the participation of local organizations in networks and how this membership might influence their performance. For analytical purposes, we discuss about the existence of horizontal and vertical networks. The first type is related to interrelations between the local organization and similar ones. The second type is related to a system of connections between the local organization and external agencies, such as ICAA, ministries and bank system, among others. The evidence shows us that organizations have a different configuration of networks and their impact on performance depends on this variability.

The evidence of horizontal networks is very scarce. Only in the initial stages of development in San Rafael there is evidence of information sharing with similar organizations. In particular, when the community was deciding to request the administration of the system to ICAA, they ask for support to nearby organizations that have initiated similar processes before.

In terms of vertical networks, in the case of San Rafael and Chirraca, the actual absence of a formal relationship with ICAA translates into a virtually nonexistent access to its legal, technical and financial support. As a matter of fact, an internal resolution from ICAA board in 2003 prohibited the provision of information and general support to any local organization that lacks delegation agreement. However, this resolution was eliminated in 2006 but kept the necessity of having a delegation agreement in order to receive financial support.

In the other two organizations the relationship with ICAA and the Central Government is more evident. In particular, in Bajo de Jorco, the links are activated whenever funds are necessary and the political context is favourable. The existence of this network is mainly because of the efforts and experience of the president of the organization. One of the most distinctive attributes of his leadership is his knowledge about the bureaucratic system at the regional and national level to access funds whenever is necessary. As a matter of fact, all major investments in infrastructure construction and replacement have been possible due to external subsidies from different agencies of the government. In the case of Desamparaditos, there has been a close relationship between the local organization for water provision and the local office of ICAA, especially because both organizations share the same water source. Governmental workers visit this area on a regular basis and provide labor support and materials whenever the community requests it.

Property rights: Based on Schlager and Ostrom (1992) we distinguished a bundle of property rights related to water and land. However, what we found is that none organization has a complete bundle of rights over all or some of the components of resource system and units. Furthermore, our empirical evidence shows that some property rights are necessary but not sufficient conditions to generate incentives to increase performance. In particular, we found that some communities seem to hesitate the exercise of some property rights because of the absence of the components of a demand driven approach. This finding, that will be discussed further ahead, might generate a lack of sense of ownership related to the resource system. The absence of a sense of ownership has been identified as one of the main reasons for infrastructure donor funded projects to fail (Gibson et al. 2005).

As stated before, one important determinant of water quality is land use management in the areas in which natural springs are located. The two organizations that show better performance have at least access and management rights over these areas. More importantly, these communities exercise these rights by enforcing specific rules to maintain land cover and limit the presence of animals or some other potential sources of contamination. On the other side, even though the organizations with lower

performance have at least the same formal rights over these areas[15], they have few incentives to devise a set of effective rules to keep these areas in good condition.

In the case of water, the State is the owner of all water in the country. However, the State could give access and withdrawal rights for defined periods to anyone who asks for. By law, all water community organizations must request these rights. Nevertheless, only Desamparaditos has a formal right to access and withdraw water from specific springs. In the other cases they have a de facto right. Even though we have no evidence that such absence of formal rights affects performance, it might the case that their capacity to deal with potential conflicts for access and use of water with external actors would be much lower.

iii. Users

Though communities have similar attributes regarding the number of families, the remoteness of community and socioeconomic characteristics (see Table 3); they still have some salient features that help to explain the observed differences on performance. In particular, the knowledge about the water system and the leadership exercise by some members of the community are key components of the human capital that positively influences outcomes on the best performing communities.

In the case of San Rafael, is particularly interesting to notice the relatively high stability of water board members (seven years on average in their actual positions). The interviews with them reveal that this factor, coupled with their attendance at some training courses on drinking water provision, give them a very good knowledge of how the local water system works. This factor increases their awareness about the relevance of preventive infrastructure maintenance and the protection of nearby areas to intake points. In addition, it is interesting to note that this organization has the highest number of committee members participating in other local organizations. This might suggest the existence of a learning effect that enhances their capability to craft and enforce rules to govern water delivery in the community.

[15] In one case the community is the owner of these lands. However, this not implies the possession of a complete bundle of rights over these areas because there is a national law that regulates the management of forests in private areas.

In the case of Chirraca, even though people with a relatively high level of formal education constitute the actual water board, their experience and specific training on water systems is very low. Furthermore, despite their willingness to cooperate with the community, sometimes it is difficult for them to dedicate enough time to deal with problems of production and provision of water in Chirraca. The reason is because of their private opportunity cost: all of them have a regular job and sometimes they have to live outside the community for short periods because of their private responsibilities. Finally, in Bajo de Jorco, despite the relatively low level of literacy and nonexistent formal training in water provision of all members of the committee, they have an enormous empirical expertise regarding the management of the system. All members have been in their actual positions for more than 7 years on average. In particular, their president has been involved in many positions in the organization for more than 50 years.

Regarding the role of leadership, we consider a leader as someone that facilitates the design of rules, norms and strategies for programs rather that a person within a program who has a higher level of authority to make decisions (Basurto 2007). The leadership is very clear and positively affects performance in San Rafael and Bajo de Jorco. In the first case, the president and the treasurer have had the ability to initiate collective-choice processes due to their organizational experience on the water board, as well in other local organizations, technical capacity, charisma and their example of commitment, ethics and conservation values. As a matter of fact, the community of San Rafael recognized this leadership recently by giving the president an award for his outstanding contributions to settlement development and water provision security.

In the case of Bajo de Jorco, the president had exercised historically a leadership role that is expressed in different ways, in particular his ability to participate in political arenas, his capacity to deal with the bureaucratic system to access funds and this expertise in technical aspects of infrastructure operation. However, a potential problem is that this strong leadership might crowd out the active participation of other members of the community in the water committee. In fact, many of the key informants in the community expressed their concern about the future of the water organization in the case of the actual president no longer being able to attend to his responsibilities.

iv. Interactions

The combination of variables from the resource system and units; the attributes of users and the governance system creates different patterns of interactions that ultimately affect performance. In this section we briefly describe some of the most important interactions observed in the field.

Demand-driven approach: It is possible to identify the following components of a demand-driven approach in some communities: initiating action, willingness to pay and participation in infrastructure and institutional design. Similar to the findings discussed in our theoretical framework, this approach seems to have a positive impact on best performing organizations but diverse forms of social capital are necessary as enabling conditions for it.

i. Initiating action: In the early 1980 the organization responsible for providing water to San Rafael and Desamparaditos was the ICAA. The interviews with key informants revealed common motivation for institutional change. The governmental administration provided a very poor service despite charging a relatively high tariff. For instance, one of most common complaint was that many breakdowns were repaired very slowly because governmental officials were located far away from the community, and they were unable to work at night or at weekends. Furthermore, a clear problem of incentives existed because officials lived outside the community and hence, they were not directly affected by breakdowns. Finally, they were accountable to the central government.

In the case of San Rafael, the general disapproval of governmental performance, coupled with the information shared with nearby communities that faced similar problems, triggered the local initiative to organize and request the administration of the system. After some negotiations, the government agreed to delegate the administration of water provision to the community in 1991. In the case of Desamparaditos, a similar process was catalyzed by the local organization for community development (Asociación de Desarrollo Integral). This organization had extensive experience in fund raising and devising effective rules for the coordination of collective action in the community. This knowledge in how to organize themselves successfully gave them confidence to start the formal petition to the government. In 1981 the central government accepted, and the community started to administer the system.

ii. Willingness to pay: Some major improvements in infrastructure were necessary at the time San Rafael and Desamparaditos were requesting the administration of the water system to the government. The government provided most of the necessary material to rebuild the infrastructure but communities have also contributed, especially with labor. In San Rafael was particularly important the contribution of local users in terms of transportation of materials as well as the technical capacity of two engineers who lived in the community. Less quantifiable, the communities also paid a higher cost in terms of negotiating with the government, as well as the cost of gathering relevant information about legal procedures and other relevant guidelines with other water community organizations and key informants. Nowadays, community members accept water charges and tariff delinquency is very low.

iii. Participation in infrastructure and institutional design: Defining and measuring participation is a difficult task because it is "multidimensional dynamic process, which takes varying forms and changes during the project cycle and over time, based on interest and need" (Narayan 1995). Having in mind this complexity, we tried to identify at least how members of the community were involved or participate in decision-making processes in different periods. More precisely, participation means that communities have relevant information about the system, their opinion is taken into account and finally, they have the opportunity to propose, modify or reject rules related to water management in their communities. In general, we found that, historically, San Rafael and Desamparaditos had have higher levels of participation of communities in decision making processes.

In early stages, when communities have received the administration of the system, they could participate actively in the definition of where and how infrastructure was replaced or built. Furthermore, they had the opportunity to craft their own local institution for water provision. The leaders and the community defined key elements such as tariffs, water board composition and election procedures, responsibilities related to operation, investment and management, among other important features. We found evidence that this element, coupled with the existence of some property rights, contributes to a sense of ownership that positively affects the desire of keeping the system working properly.

Nowadays, participation is expressed in diverse forms. First, the attendance to regular assemblies is relatively high in San Rafael and Desamparaditos. These are important meetings for sharing information about results and future plans. Second, more than 50% of interviewed users mentioned that they had the opportunity to vote for approving or denying rule changes or plans proposed by the committee. Besides this, users have the opportunity to participate in election processes for the committee. Finally, all interviewed users reveal that want to keep the actual institutional arrangement as opposed to a governmental administration. The main reasons for this willingness to keep the actual governance structure are related to the perception of good performance and acceptance of decisions adopted by actual organization (more than 60% of interviewed users expressed their approval of committee decisions in last two years) as well as the fear that an eventual governmental organization will charge higher tariffs and will offer a poorer service, like in previous decades.

Motivational problems: We found evidence of the tendency of local users to free-ride on others effort to provide and produce the necessary infrastructure and governance structure. This motivational problem is exacerbated by the lack of enforceable rules to deter free-riding as well as physical characteristics of the resource system.

The clearest example of motivational problems related to the support from the governmental was found in Bajo de Jorco. The strong leadership exercised by the president has substituted the active participation of the rest of the community. In many cases, most of the members of the community have acted as passive observers, free riding on the efforts and ability of the president to obtain funds from the central government. Furthermore, this double dependence (on the president and external funds) seems to create two perverse incentives that further increase dependency. First, it reduces the incentives to raise local funds. In fact, this organization has the highest delinquency rate among all organizations. Furthermore, when users were asked about a hypothetical situation in which the infrastructure must be replaced, only 44% answered that they are willing to pay for the associated costs (In San Rafael and Desamparaditos, the answers were 67% and 80% respectively). Second, most users act as passive observers of the work done by the president and the rest of the committee. The low rotation rate of the committee members discussed before, the low attendance to regular

meetings and general assemblies to share information and to vote, are pieces of evidence in this regard.

On the other hand, there are free-riding incentives that help explain the absence of effective rules that aims to solve collective action problems related to drinking water in Chirraca. In the early days of the system, one family constructed the infrastructure of conduction and distribution. Because of family or friendship ties, some other families started to connect themselves to the system. The pioneer family never charged a fee or prohibit others from connecting to the system. Despite a rapid population growth that has created allocation problems, as well as threats to water quality from agricultural activities and infrastructure deterioration, there is a strong opposition from users to set tariffs and regulate water consumption. As a result, the original set of rules is completely inadequate to overcome the new challenges.

Information sharing: In a hierarchical situation, the superior defines what, how, when and where a subordinate works; and evaluates the performance based on these instructions (Gibson et al 2005). However, the effectiveness of these principal-agent relationships relies heavily on the existence of perfect information about agent´s actions. We found that many hierarchical relationships that exist in relation to water community organizations are flawed because of asymmetric information problems.

The first hierarchical situation that we have analyzed is the relationship between the water community organizations, as agents, and the ICAA, as principal. In formal terms, all drinking water community organizations are formally accountable to ICAA. Nevertheless, the ICAA in immersed into a complex legal hierarchy in which the MINAET (Ministerio de Ambiente, Energía y Telecomunicaciones) is the maximum authority for water resources in Costa Rica (for all uses). Furthermore, it is reported that more than 20 public entities have jurisdiction over water resources and more than 110 norms regulate the sector (Aguilar et. al 2004, cited by GWP 2006).

This scenario creates many ambiguities; in particular, to define which governmental entity is the ultimate responsible for oversight water community organizations. In addition, given that many of these communities are very small and located in remote areas, additional incentives are in place to leave communities without any control in practice from the government. Even in the case of ASADAS,

we found no evidence of any direct and permanent supervision from the government, even though all have signed a detailed delegation agreement with ICAA. Furthermore, this might constitute a clear indicator that the delegation agreement is a set of written rules with reduced enforceability. In this context, it not a surprise that we found no significant change in the structure of incentives that affects performance in organizations that were transformed from CAARs into ASADAS.

Another hierarchical situation is related to water committees, as agents, and users, as principal. In all analyzed cases, users elect members of water committees. However, users have limited information about their actions. Nevertheless, some communities have devised specific rules to reduce the problem of asymmetric information. As we discussed before, the high performing organizations have clear mechanisms for downward accountability, such as well defined procedures to recall, public written and oral reports and formal and informal arenas in which officials can be sued. These mechanisms have been effective means to inform communities about the accomplishment of tasks by committee members.

6. CONCLUSIONS

Like similar studies in the literature, the demand-driven approach seems to be an important causal condition associated with good performance. The desire of communities to organize themselves for water provision, their involvement in design of infrastructure and institutions, as well as their willingness to pay for infrastructure construction and maintenance are crucial elements that positively affect performance. However, we found that this approach does not seem to be sufficient condition. In particular, the existence of downward accountability is a crucial characteristic of the governance structure that increases the likelihood that water users desires are reflected in the actions of the water committee.

Given our research design, we cannot test if one formal institutional arrangement (CAAR or ASADA) was superior to another to achieve good performance. However, we could understood that in some cases the set of effective rules affects the achievement of certain tasks is similar, either being CAAR or ASADA. Therefore, there was nothing inherently favourable in being a CAAR or ASADA, all

depends in how effective rules solve adequately the production and provision problems in these settings.

Our theoretical framework helped us to deal with the complexity of determinants of performance. Furthermore, it was very useful to demonstrate that performance is the result of a configuration of variables from the resource system, the users and the governance system. Public policies that aim to increase performance in water community organizations must recognize this complexity in order to be effective. From this perspective, there are some policy implications derived from our analysis. First, it is very difficult that a general governmental prescription that ignores the interests of those affected by the policy will generate the appropriate incentives to solve collective action problems related to drinking water provision in every community. In particular, changes in formal rules promoted by central government do not necessarily affect performance. We founded no empirical evidence that the transformation of CAARs into ASADAS, promoted by ICAA, generates additional incentives to change the behaviour of actors involved. The low enforcement capacity of the government and the inadequate adaptation of formal rules to the particularities of communities explain why this policy blueprint is incapable to generate incentives that ensure an adequate provision of water in rural areas.

Second, governmental subsidies might create long-term financial dependence. The generation of perverse incentives that crowed-out local contributions and thus, reduce the motivation for financial self-sufficiency must be taken into account when supporting local organizations. Finally, the support from government must emphasize in designing policies and incentives that promotes enabling conditions for local organizations. Some of the most important needs detected is the provision of information and technical studies for delimitation of recharge areas and the restoration of degraded ecosystems. Permanent and accessible training programs in technical aspects of infrastructure and management are also key elements to increase local capacities to manage water system over time.

From the methodological point of view, the core conceptual variables listed using adapted SESs framework represent our starting point to understand the determinants of performance. Our qualitative analysis helped us to determine which configuration of variables from this compilation (not exhaustive) were relevant for understanding the causal mechanisms that explain outcomes in drinking water

community organizations. From this point, scholars might try to test if some of the mechanisms and variables identified are statistically significant for a broader population.

7. BIBLIOGRAPHY

Agrawal, A; Ribbot, J. 1999. Accountability in decentralization: a framework with South Asian and African cases. Journal of Developing Areas 33: 473-502.

Agrawal, A. 2001. Common property institutions and sustainable governance of resources. World Development Vol 29, No.10. 1649-1672.

Agrawal, A; Ostrom, E. 2001. Collective action, property rights, and decentralization in resource use in India and Nepal. Politics and Society, Vol 29, No. 4, 485-514 pp.

Anderies, J; Janssen, M; Ostrom, E. 2004. A framework to analyze the robustness of social-ecological systems from an institutional perspective. Ecology and Society 9(1): 18.

Araral, E. 2006. Decentralization puzzles: a political economy analysis of irrigation reform in the Philippines. PhD Dissertation. Indiana University. 380 p.

Basurto, X. 2007. Policy, governance and local institutions for biodiversity conservation in Costa Rica. PhD Dissertation, The University of Arizona.

Berg, S; Corton, M. 2007. Benchmarking water utilities: Central America. Public Utility Research Center, University of Florida.

Berg, S; Lin, Ch. 2007. Consistency in Performance Rankings: The Peru Water Sector. Forthcoming in Applied Economics.

Bruijnzeel, L.A. 2004. Hydrological functions of tropical forests: not seeing the soil for the trees?. Agriculture, Ecosystems and Environment 104 (2004) 185–228. Faculty of Earth and Life Sciences, Vrije University.

Corton, M. 2003. Benchmarking in the Latin American water sector: the case of Peru. Utilities Policy 11 133–142.

Dehejia, R; Wahba, S. 2002. Propensity score matching methods for non-experimental causal studies, Discussion Papers 0102-14, Columbia University, Department of Economics.

Flyvbjerg, B. 2006. Five misunderstandings about case-study research. Qualitative Inquiry. Volume 12, Number 2. pp 219-245

Gerring, J. 2007. Case study research: principles and practices. Cambridge University Press, 265 p.

Gibson, C; Andersson, K; Ostrom, E; Shivakumar, S. 2005. The Samaritan´s Dilemma: The political economy of Development Aid. Oxford University Press. 264 p.

Gross, van Wijk-Sijbesma. 2001. Linking sustainability with demand, gender and poverty. World Bank Technical

International Forestry Resources and Institutions (IFRI). 2007. Field Manual. Research Program, Indiana University.

Kähkönen, S. 1999. Does social capital matter in water and sanitation delivery? A review of literature. Social Capital Initiative. Working Paper No. 9. The World Bank, Washington. 45p.

Kleemeier, E. 2000. The impact of participation on sustainability: an analysis of the Malawi rural piped scheme program. World Development Vol. 28, No. 5, pp. 929-944.

Knox, A; Meinzen-Dick, R. 2001. Collective action, property rights and devolution of natural resource management: exchange of knowledge and implications for policy. CAPRi Working paper 11. IFPRI-CGIAR. 71 p.

Meinzen-Dick, R. 2007. Beyond panaceas in water institutions. PNAS. National Academy of Sciences of the USA. Vol. 104: 39. pp. 15200–15205

Narayan, D. 1995. The contribution of people's participation: evidence from 121 rural water supply projects. Environmentally Sustainable Development Occasional Paper Series No1. The World Bank, Washington DC.

Ostrom, E, Schroeder, L; Wynne, S. 1993. Institutional incentives and sustainable development: infrastructure policies in perspective. Boulder, CO: Westview Press.

Ostrom, E. 1990. Governing the commons: the evolution of institutions for collective action. Cambridge University Press. 280 p.

Ostrom, E. 2007. A diagnostic approach for going beyond panaceas. Proceedings of the National Academy of Sciences of the United States of America (PNAS), Vol 104(39): 15181-15187

Ostrom, E; Janssen, M. A.; Anderies, J. M. 2007. Going beyond panaceas special feature: going beyond panaceas. Proceedings of the National Academy of Sciences of the United States of America, Vol 104(39): 15176 - 15178 p.

Poteete, A; Ostrom, E. 2008. Fifteen Years of Empirical Research on Collective Action in Natural Resource Management: Struggling to Build Large-N Databases Based on Qualitative Research. World Development Vol. 36, No. 1, pp. 176–195.

Ribot, J. 2004. Waiting for democracy: the politics of choice in natural resource decentralization. World Resources Institute. Washington, DC. 154 p.

Saleth, M; Dinar, A. 2004. The institutional economics of water: a cross country analysis of institutions and performance. World Bank-Edward Elgar. 398 p.

Sara, J; Katz, T. 1997. Making rural water supply sustainable: report on the impact of project rules. Water and Sanitation Program, UNDP-World Bank. 53 p.

Schlager, E. and E. Ostrom. 1992. Property-rights regimes and natural resources: A conceptual analysis. Land Economics 68(3) (Aug.): 249–262.

Seawright, J; Gerring, J. 2008. Case selection techniques in case study research. A menu of qualitative and quantitative options. Political Research Quaterly. Volume 61, November 2, 294-308

Stalker, L. 2005. The Relationship between Participation and Project Outcomes: Evidence from Rural Water Supply Projects in India. World Development Vol. 33, No. 11, pp. 1801–1819.

UNDP. 2006. Human Development Report. Beyond scarcity: Power, poverty and the global water crisis. UNDP, NY. 440p.

WHO-UNICEF. 2008. Joint monitoring programme for water and sanitation. http://www.wssinfo.org/en/238_wat_latino.html, consulted august 29th, 2008.

8. APPENDIX A

Table A1.
RESOURCE SYSTEM (RS)
Second, third and fourth tier variables

RS1: Clarity of system boundaries
- RS1a: Infrastructure
- RS1b: Recharge areas

RS2: Infrastructure characteristics
- RS2a: Age
- RS2b: Metering
- RS2c: Size of aqueduct
  - # of service lines
  - Length of aqueduct
  - Density of service lines
- RS2d: Feeder technology

RS3: Location
- RS3a: Remoteness

RS4: Scarcity: relative water supply (stock)

RS5: Predictability of system dynamics
- RS4a: Effect of shocks such as droughts and floods; earthquakes

RS6: Type of water source
- RS5a: Type of source: superficial, groundwater

RS7: Watershed characteristics
- RS7a: Precipitation
- RS7b: Temperature
- RS7c: Bio-physical condition of recharge area (deteriorated, protected)
- RS7d: Potential sources of contamination, principal productive activities in nearby areas
  - land use patterns
  - agrochemical use
  - sewage disposals

Table A2.
GOVERNANCE SYSTEM (GS)
Second, third and fourth tier variables

GS1: Type of organization

- GS1a: Legal status, official recognition.

GS2: Accountability:

- GS2a: Procedures to recall[16]
- GS2b: Public reporting requirements
- GS2c: Arenas in which officials can be sued, legal recourse[17] through courts
- GS2d: Auditing and evaluation (internal vs external)
- GS2e: Performance awards
- GS2f: Election processes
- GS2g: Informal arenas

GS3: Network structure

- GS3a: Vertical and horizontal networks
  - ICAA, Ministry of Health, Ministry of Environment
- GS3b: Benefits from network participation
  - Direct subsidies (cash; in-kind)
  - Information sharing
  - Technical training

GS4: Property rights

- GS4a: Withdrawal, management, exclusion, alienation rights in regard to:
  - Land (recharge areas)
    - Criteria to define recharge areas (scientific, legal vs popular basis)
  - Water (resource units)

GS5: Operational rules

- GS5a: Type of tariffs (volumetric, fixed, by household size, irregular collections, no tariffs)
  - Monitoring and sanctioning procedures for delinquency
  - How are these rules defined? Who is in charge of this?
- GS5b: Maintenance (preventive vs corrective)
  - Breakdowns: how are detected? Who repairs them? How fast are repaired? How are financed?
  - Recharge areas: fencing, fire prevention, general activities for protection
  - How are these rules defined? Who is in charge of this?
- GS5c: Resource mobilization and account keeping
  - Do tariff revenues have a well-defined use?
  - Record of users
  - How do they collect revenues?
  - Accounting methods, financial records
  - Access to formal banking system
  - How are these rules defined? Who is in charge of this?

[16] The act of putting an end to something planned or previously agreed to.
[17] Something that one uses to accomplish an end especially when the usual means is not available.

- GS5d: Water treatment and monitoring
  - Monitoring of water quality and treatment (Chloride, purification)
  - Quantity assessment
  - How are these rules defined? Who is in charge of this?

GS6: Collective-choice rules

- GS6a: Responsibilities of the organization (operation, investment, management, provision)
- GS6b: Election of officials
- GS6c: Conflict resolution arenas
- GS6d: Involvement of communities in devising collective-choice rules
- GS6e: How are these rules defined? Who is in charge of this?

GS7: Constitutional rules (prescribing, invoking, monitoring, applying, enforcing)

- GS7a: Ex-ante controls and civil service system
- GS7b: Water pricing policies

Table A3.

USERS (U)

Second, third and fourth tier variables

U1: Number of beneficiaries

U2: Socioeconomic attributes

U3: History of use

- U3a: Origen of the community

U4: Human capital

- U5a: Leadership
  - How leadership is expressed?
- U5b: Knowledge of water drinking systems
  - Do local people understand the connection between the activities in recharge areas and water provision (quality and availability)?
  - Do local people know where the recharge areas are located?
  - Do they realize the principal threats (actual and future) to access and use drinking water?
- U5c: Characteristics of the water committee
  - Number of members, description of positions (technical vs administrative)
  - Elected, appointed
  - Socioeconomic characteristics (members of the community?)
  - Knowledge of the system: experience, training, concerned about underinvestment on maintenance
  - Women participation
  - Salary

U5: Social capital

Table A4.
INTERACTIONS (I)
Second and third tier variables

I1: Demand driven approach

- I1a: Initiating action
- I1b: Willingness to pay
- I1c: Participation in infrastructure and institutional design

I2: Motivational problems

- I2a: External dependence

I3: Information sharing

- I3a: Principal agent relationships

Table A5.
OUTCOMES (O)
Second and third tier variables

O1: Financial performance

- O1a: Fee collection
- O1b: Cost recovery
- O1c: Investment self-sufficiency

O2: Physical performance

- O2a: Sping condition
  - Existence of an adequate fence
  - Infrastructure (concrete box) for protection of intake point
  - Adequate inspection cover
  - Intake point infrastructure with no major cracks
  - Pending angle to avoid water accumulation in top of infrastructure
  - System to divert run-off from intake point
  - Apparent cleanliness of intake point (absence of plants, roots, sediments, leaves or algae)
  - Grille for protection of overflow system
  - Good conservation of areas around intake point (absence of latrines, animals, houses, trash or public streets in a 20 meters radius)
  - Intake point has no direct influence from agricultural or cattle farming (intake point it is not located downstream of agricultural or cattle farming)
- O2b: Storage tank condition
  - Walls in good condition (no cracks in case of concrete or rust in case of metal)
  - Inspection cover with appropriate design and closing system
  - Existence of concrete sidewalk of at least 0.8 mts around tank
  - Roof or superior side of tank in good condition and waterproof
  - Water level is higher than a 1/4 of total volume
  - Apparent internal cleanliness of tank (absence of sediments, roots, algae or

fungus inside)
- Fence to protect tank
- Good condition of plot in which tank is located (absence of trash or bushes)
- Absence of potential sources of contamination (absence of latrines, animals, houses, trash or public streets in a 20 meters radius)
- Protection grill for air and overflow system

o O2c: Conveyance infrastructure
- Conveyance pipes in good condition (no evident distribution and conveyance losses)
- Good protection of pipes (pipes are not exposed nor vulnerable to natural disasters or accidents)
- Overpass lines in good condition
- Existence of a system to clean (purge) conveyance system and disinfection procedures after maintenance

o O2d: Water quality assessment
- Microbiological criteria on potability

O3: Consumer satisfaction

o O3a: Permanent water service
o O3b: Satisfaction with water quantity at home
o O3c: Illness caused by tap water consumption
o O3d: Perception of work done by local organization to provide water

9. APPENDIX B

Table B1. Rules in use index				
These indicators show the existence of different *rules in use* in the communities. All indicators are dummy variables. 1 means presence of the rule; 0 means nonexistence.	**San Rafael de Arriba**	**Chirraca, Los Calderón**	**Desampa-raditos**	**Bajo de Jorco**
COLLECTIVE CHOICE RULES. *TOTAL*	**6**	**1**	**6**	**1**
There is a written regulation designed by the community. This set of working rules seem to work effectively	1	0	1	0
A general assembly is held periodically	1	0	1	0
The committee have periodical meetings	1	0	1	1
There is clear and periodical mechanism for election of committee	1	1	1	0
There are accepted procedures to remove members of the committee before election	1	0	1	0
There are accepted and known procedures to reach decisions in water committee meeting	1	0	1	0
OPERATIONAL LEVEL RULES. *TOTAL*	**17**	**4**	**11**	**4**
About tariffs				
The water use is regulated by metering systems and tariffs	0	0	1	1
The place, days and mode of payment are clearly established	1	1	1	0
Sanctions about delinquency are clearly established and enforced	1	0	1	0
Sanctions about delinquency are gradual according to the days of delay and there are reconnection costs.	1	0	0	0
About infrastructure maintenance and protection				
Rules about preventing maintenance of infrastructure are enforced	1	0	0	0
Rules for breakdowns repairing are enforced	1	1	1	1
Rules for protection of natural areas near intake points	1	0	1	0
About water treatment				
Monitoring of water quality (microbiological tests paid by committee)	1	0	0	0
Tanks are cleaned periodically	1	0	0	0
Accountability				
Nowadays the organization have the following types of registers:				
• Users list	1	1	1	1
• Delinquency list	1	0	1	0
• Annual o monthly budgets	1	0	0	0
• Financial statements	1	0	1	0
• Accountancy books	1	1	1	1
• Labor paper reports	1	0	0	0
There is a defined place to file relevant documents	1	0	0	0
Written reports of activities done by committee to users	1	0	1	0
Written reports of activities done by committee to ICAA	0	0	1	0
An established mechanism for periodical information on future meetings, infrastructure maintenance, etc	1	0	0	0
TOTAL	**23**	**5**	**17**	**5**