Documentos CEDE
ISSN 1657-5334

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26
NOVIEMBRE DE 2009

Universidad de los Andes
Facultad de Economía

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Centro de Estudios sobre Desarrollo Económico

Serie Documentos Cede, 2009-26
ISSN 1657-5334

Noviembre de 2009

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Edición, diseño de cubierta, preprensa y prensa digital:
Proceditor ltda.
Calle 1C No. 27 A – 01
Bogotá, D. C., Colombia
Teléfonos: 2204275, 220 4276, Fax: extensión 102
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Impreso en Colombia – *Printed in Colombia*

Universidad de los Andes
Facultad de Economía

CEDE
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COLLECTIVE ACTION FOR WATERSHED MANAGEMENT: FIELD EXPERIMENTS IN COLOMBIA AND KENYA[1]

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ABSTRACT

The dilemma of collective action around water use and management involves solving both the problems of provision and appropriation. Cooperation in the provision can be affected by the rival nature of the appropriation and the asymmetries in the access. We report two field experiments conducted in Colombia and Kenya. The *Irrigation Game* was used to explore the provision and appropriation decisions under asymmetric or sequential appropriation, complemented with a *Voluntary Contribution Mechanism experiment* which looks at provision decisions under symmetric appropriation. The overall results were consistent with the patterns of previous studies: the zero contribution hypotheses is rejected whereas the most effective institution to increase cooperation was face-to-face communication, and above external regulations, although we find that communication works much more effectively in Colombia. We also find that the asymmetric appropriation did reduce cooperation, though the magnitude of the social loss and the effectiveness of alternative institutional options varied across sites.

Key words: Collective Action, Watersheds, Field Experiments, Colombia, Kenya.
JEL classification: Q0, Q2, C9, H3, H4.

[1] The work presented in the paper was conducted as part of the project "Sustaining Collective Action that Links Economical and Ecological Scales" (SCALES –PN20) of the CGIAR Challenge Program on Water and Food. This project was led by the Centro Internacional de Agricultura Tropical (CIAT) and the partners involved in the economic games were the Universidad de los Andes, World Wide Fund for Nature (WWF)- Colombia, Semillas de Agua, Fundación Humedales and The World Agroforestry Centre (ICRAF)..

ACCIÓN COLECTIVA PARA EL MANEJO DE CUENCAS:

EXPERIMENTOS EN CAMPO EN COLOMBIA Y KENIA

RESUMEN

El dilema de la acción colectiva alrededor del uso y manejo del agua implica resolver tanto los problemas de provisión como de apropiación. La cooperación en la provisión puede verse afectada por la rivalidad en la apropiación y las asimetrías en el acceso. En este documento presentamos dos experimentos llevados a cabo en Colombia y Kenia. El *Juego de la Irrigación* fue usado para explorar las decisiones de provisión y apropiación, bajo unas condiciones de apropiación asimétricas o secuenciales, complementado con el experimento de *Voluntary Contribution Mechanism* el cual se enfoca en las decisiones de provisión bajo condiciones de apropiación simétricas. Los resultados generales fueron consistentes con los patrones de estudios previos: la hipótesis de cero contribución es rechazada, al tiempo que la institución más efectiva para aumentar la cooperación fue la comunicación cara a cara, por encima de las regulaciones externas; sin embargo, encontramos que la comunicación funciona mucho mejor en Colombia que en Kenia. Igualmente, encontramos que la asimetría en la apropiación reduce la cooperación, aunque la magnitud de la pérdida social y la efectividad de las opciones institucionales varían entre los sitios estudiados.

Clasificación JEL: Q0, Q2, C9, H3, H4.

Palabras claves: acción colectiva, cuencas hidrográficas, agua, experimentos económicos, Colombia, Kenia.

1. Introduction

There is wide evidence that cooperation can improve natural resource management. Cooperation can be particularly important in watershed contexts where the action of individuals often have widespread spillover effects, and there is strong interdependence among the people in different geographical locations. Collective action around water in a watershed context involves both the provision and the appropriation of the resource. Provision decisions determine how much water will be available. In a watershed context they refer to actions taken, mainly in upper watershed but possible financed by resources downstream, to maintain or increase the quantity and quality of flows. Appropriation decisions are the decisions that people make about how much water to abstract. Abstraction decisions are asymmetric in that people upstream will always have first access to water supplies. The cooperation needed for water provision can be undermined by the rival nature of the resource and the asymmetries in its appropriation. This helps explain why achieving and maintaining collective action in watershed management is particularly challenging (Swallow et al, 2006).

This paper is an effort to identify the factors that facilitate collective action in watershed contexts characterized by significant externalities where the land and water use decisions of some individuals affect the options available to others. By using economic experiments, it is possible to identify the factors that affect individuals' decisions about cooperation, including both economic incentives and attitudes and perceptions about equity and fairness. Following Ostrom (1998) the crucial variables hypothesized to enhance cooperation in regard to common pool resources (CPRs) are those that related to reciprocity, individual reputations, and trust. Games can be designed specifically to test the effectiveness of alternative institutional options for stimulating collective action by strengthening reciprocity, reputation and trust. For example, there is ample evidence about the critical importance of communication in CPR dilemmas, even more than exogenous rules that are monitored at realistic levels (Ostrom, 2006; Cardenas, 2004). Additionally, the results of the games played in two different countries and four different watersheds permit the cross-country and cross-watershed comparative analysis that allows us examine the influence of the context, in terms of socio-economic, political, cultural and agro-ecological features, on collective action outcomes.

We present here the results of a series of field experiments conducted in Fuquene Lake and Coello River watersheds in the Colombian Andes and Awach and Kapchorean River watersheds in the Nyando Basin in western Kenya. We recruited around 500 watershed inhabitants from upstream, midstream and downstream locations of the four watersheds. The demographics of these people can be found in Table 7. We implemented a new experimental design called the *Irrigation Game* developed by Cardenas et al (2008) that includes the provision and appropriation nature of the water management. The experiments also included the canonical version of a public goods or VCM (*Voluntary Contribution Mechanism*) game. The *Irrigation Game* introduces the asymmetries in appropriation that are usual in water provision system contexts because of the downstream sequence among appropriators. The results can be compared to our VCM results where individuals have a symmetric and simultaneous access to the same common-pool in order to evaluate the costs associated with asymmetries and assess the potential benefits of alternative intervention options.

In Section 2 we describe a theoretical framework for understanding issues and challenges that affect collective action in a watershed context. Section 3 provides a description of the watersheds where the experiments were conducted, and in Section 4, the experimental designs are described. Section 5 presents the main socioeconomic variables included in the survey and the main results of the provision decisions in the four watersheds. Section 6 provides the results of regression analysis about the factors that improve cooperation around water in watersheds contexts. The paper ends with an analysis of the results and a discussion of the conclusions derived from the analysis and their implications for policy.

2. SCALES Theoretical Framework: Collective Action around Water and Watersheds

Collective action is key to achieve sustainable water and watersheds management. The nature of water resources and the externalities present in watersheds impose the necessity to look for common solutions to water-related problems. These can range from neighbors managing a shared water point to a large number of stakeholders from different towns, cultural groups, social classes and economic sectors negotiating to govern the dealing with the vertical flows of water, nutrients and soil across a watershed. The vertical nature of the watershed produces asymmetries in water access and these are often compounded by the fact that stakeholder in watershed management are heterogeneous and often do not know each other, because of their locations, have limited or sometime no interaction that would enable them to build trust and resolve conflicts (Swallow et al, 2006).

Watershed contexts are characterized by a variety of actors, e.g., farmers, livestock keepers, mining companies, municipal land use planners, and urban water suppliers, who make decisions or take specific actions related to water or other landscape resource such as farm land, forests, or pastures. These actors are heterogeneous in terms of water access, economic activities and power to influence institutional arrangements for water management. According to Knox et al (2001) previous research in collective management of watershed resources show that robust collective management is likely to depend on the level of existing community organization and social capital, that is *"the strength of norms and social relations that enable people to work together to* *achieve their goals".* At higher scales, however these norms and relations are likely to be weak, and need to be replaced by formal institutions. The nested nature of watershed is reflected in the nest and overlapping institutional scales at which watershed management can occur, often leading to "forum shopping" where actors seek to address issues with the institutions most likely to find in their favor. The modalities for managing collective action are also likely to vary by scale, for example direct communication and negotiation is likely to work best at a local scale among homogenous stakeholders whereas formal rules may be best at higher scales for controlling the behavior of heterogeneous actors.

Heterogeneity has been a frequent theme of concern in the collective action literature, including the seminal hypothesis by Olson (1965) that in heterogeneous groups it will be the privileged group that would provide the public good inducing the non-privileged to free-ride on the provision of the former. The experimental literature on heterogeneity and cooperation is substantial as well as diverse in the confirmation and rejection of the Olson's hypothesis. Hackett et al (1994) conducted a series of CPR experiments to explore whether community could reduce the problems related to heterogeneity among appropriators and found that *"the task of agreeing to and sustaining agreements for efficient CPR appropriators is more difficult for heterogeneous groups because of the distributional conflict associated with alternative sharing rules. In heterogeneous settings, all appropriators may be made better off by adopting a new rule, but some will benefit more than others, depending upon the sharing rule chosen. Consequently, appropriators may fail to cooperate on the adoption of a sharing rule because they cannot agree upon what would constitute a fair distribution of benefits produced by cooperating".* Cardenas (2003) provides experimental evidence from the field using a CPR design showing that the social distance among the players decreases the possibilities of cooperation; Cardenas et.al (2002) also test the role of heterogeneity in the level of cooperation by assigning asymmetric payoffs structures in the incentives for the players, confirming that those with better outside options tend to behave closer to the Nash self-oriented prediction whereas those with poorer outside options tend to converge more towards a group-oriented strategy of cooperation. In all these studies the opportunity to communicate leads to a noticeable change in the pattern of allocation, *"even in an environment of extreme heterogeneity in subject endowments, communication was a powerful mechanism for promoting coordination, resulting in rents very close to those observed in the homogeneous set*" (Ostrom, 2006).

3. Watersheds Description

3.1. Fuquene Lake Watershed[2]

The Fuquene Lake and Coello River watersheds are typical of the socio-environmental situation in the Andes (Ramirez and Cisneros, 2006). Fuquene Lake watershed (Fuquene) encompasses the valleys of Ubaté and Chiquinquirá in the states of Cundinamarca and Boyaca, Colombia. Fuquene is located about two hours from the Colombian capital, Bogotá, on a good all-weather road. It covers an area of 187,200 ha including 17 municipalities[3,] with a population of 229,000 inhabitants (Rubiano et al, 2006), about 59% of which is rural (DANE, 2005). The altitude ranges from 2300-3300 meters above the sea level (masl), with an annual rainfall between 700 and 1500 mm. For the municipalities in the watershed, the 2003 Life Condition Index, a measure of welfare, ranged between "very low" and "high" (Sarmiento et al, 2006), reflecting the socioeconomic heterogeneity in the zone.

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[2] For more information see http://www.infoandina.info/andean/index.shtml?apc=Ba1e1-&s=B&e=h

[3] The municipalities that belong to the Fuquene watershed are Carmen de Carupa, Ubate, Tusa, Sutatausa, Cucunubá, Suesca, Villapinzón, Lenguazaque, Gachetá, Fúquene, Susa y Simijaca in Cundinamarca and San Miguel de Sema, Ráquira, Caldas, Chiquinquirá y Saboya in Boyacá.

The largest land use in the watershed is pasture (59%), followed by agriculture (26%), forest (4%), *páramo* (2%) and lake (2%) (Rubiano et al, 2006). Land degradation is a serious concern, with 13,000 hectares classified as severely eroded and 40,000 as moderately eroded. The principal economic activities in the watershed are agriculture (cropping and dairy) and mining. The medium and large scale dairy operations, located in the lower part of the watershed along the shores of the lake, are high input and highly productive. Land values in this area are among the highest in the country, and many hacienda owners are wealthy and politically well connected. Crops are grown mainly in the upper and middle parts of the watershed. Land ownership in upper and middle part of the watershed is generally by smallholders, however in the higher areas appropriate for potato cultivation, much of the land is rented out to large-scale producers who better able to take this risks associated with this high-risk-high-reward crop. Despite the fact that it is against environmental regulations, significant cultivation occurs in the *páramos*, which are ecologically fragile and play a key role in maintenance of ecosystem function, especially supply and regulation of water flow (Rangel, 2006).

Lake Fuquene[4] is located at the bottom of the watershed, is at the center of environmental controversy. The health of the lake, mainly for biodiversity but increasingly as a provider of environmental services such as tourism and urban water supplies and flood control, is currently driving change in the watershed (Johnson et al, 2009).

The environmental authority for the Fuquene watershed, the *Corporacion Autonoma Regional de Cundinamarca (CAR)*[5] is responsible for developing and implementing the watershed management plan, and there is widespread discontent with their inaction. Local municipal governments have some responsibility for resolving water conflicts and for undertaking

[4] See http://www.livinglakes.org/fuquene/.
[5] See http://www.car.gov.co

conservation activities. While some are more active than others, they are limited in what they can achieve given their purely local scope. There are few NGOs or civil society organizations working in Fuquene. Local universities and international organizations have a research presence, but until very recently, little had been done in terms of mobilizing communities to address issues at the watershed level, politically (Candelo et al, 2008)

3.2. Coello River Watershed

The Coello River watershed, located the state of Tolima in the central Andean Cordillera covers an area of 190,000 ha ranging from 280 to 5300 masl. Annual rainfall ranges from below 1000 mm to more than 3970 mm. The watershed includes ecosystems ranging from dry forest to *páramo* to snow-capped peaks, and is home to national parks and private reserves. The watershed contains some or all of eight municipalities[6] with a population of 622,395 in 2005, including the city of Ibagué (pop. 425,770). Counting this city, only 16% of the population is rural and even without Ibague urbanization rates are above 50%. The Life Condition Index for municipalities in the Coello watershed range from "medium low" to " medium high," a slightly narrower range than for Fuquene, with urban municipality scoring higher than rural ones (Sarmiento et al, 2006). The Pan-American Highway passes through the watershed, generating economic activity but at a cost of soil erosion and air pollution (Johnson et al, 2009).

Main economic activities in Coello include agriculture and livestock. The upper part of the watershed is mainly forested, however land there is increasingly being converted into pastures for livestock, coffee and horticultural crops. In the middle altitude areas, sugar cane and fruit trees are common; this regional accounts for 30% of Colombia's fruit and vegetable production (Fujisaka, 2007). The lower part of the watershed includes 30,000 ha of large-scale, irrigated

[6] The municipalities that make up the Coello River watershed are Ibagué, San Luis, Rovira, Cajamarca – Anaime, Espinal, Flandes, Valle del San Juan y Coello.

rice, cotton, and sorghum as well as beef cattle. Rice demands the largest share of water channeled through the rivers and irrigation systems (500 million m^3) followed by fruit (41 million m^3) and coffee (1.5 million m^3) (Fujisaka, 2007). The environmental authority responsible for the Coello watershed is the *Corporacion Autonoma de Tolima* (*CorTolima*). Progress on a comprehensive plan has been slow. Water has not traditionally been scarce in Coello, however there is growing awareness that inappropriate land use in the upper watershed combined with growing demand for irrigation, domestic water and hydroelectric power in the lower areas are rapidly leading to a situation that is not sustainable (Johnson et al, 2009). While in Fúquene the main environmental emphasis was on the lake at the bottom of the watershed, in Coello the process focuses on conserving the upper parts of the watershed. Some NGOs are working to preserve *páramos* and in doing so they are seeking to link with downstream stakeholders who are benefiting or could benefit from the environmental service provided by the *páramos* (Candelo et al, 2008)

3.3. Nyando Basin

The Nyando river basin is located in Western Kenya where it drains into the world's second largest freshwater lake, Lake Victoria. In turn, Lake Victoria is an important component of the Nile river system. While the Nyando is small compared to some of the other basins that make up the Lake Victoria and Nile systems, it has a heavy influence on the ecology of Lake Victoria. Large amounts of sediment and other pollutants are carried along the three main tributaries of the Nyando, contributing disproportionately to the sedimentation and eutrophication of the Lake Victoria ecosystem. The Nyando basin spans from the Mau forest in the upper reaches, through a range of farming systems, to an alluvial plain and wetland where the river enters Lake Victoria. Altitudes vary from about 1100 masl in the flood plain near Lake Victoria to almost 3000 masl in some parts of the Mau forest in the upper-most areas. The basin has three main tributaries, the Awach in the south, the Kapchorean in the middle and the Ainabgetuny in the north. The basin is heavily modified, with large-scale deforestation in the upper basin and wetland conversion in the lower basin (World Agroforestry Center, 2006; Swallow et al, 2007)

The Nyando basin covers an area of approximately 3,517 square kilometers and had a population of approximately 746,000 people (Mungai et al, 2004). At that time, the average population density was 212 persons per square kilometer across the basin, with some areas supporting up to 750 persons per square kilometer and other areas with as few as 50 persons per square kilometer. As of 1997 the incidence of poverty, as measured by food purchasing power in Kenya's poverty mapping study, was generally high in the Nyando basin, with an average poverty incidence of 58 percent in Kericho District, 63 percent in Nandi District, and 66 percent in Nyando District, compared to the national average of 53 percent (Central Bureau of Statistics, 2003). HIV/AIDS prevalence is 28 percent in Nyando District, seven percent in Nandi District, and 12 percent in Kericho District (Swallow et al, 2005). The basin is primarily inhabited by two ethnic groups: the Luo who occupy the lowlands and part of the midlands and the Kalenjin who occupy the highlands. Small numbers of a third ethnic group, the Ogiek, occupy parts of the forest margin at the uppermost parts of the basin. Almost all the basin falls in the three administrative districts of Nyando, Nandi and Kericho, with small portions of the basin in other neighboring districts (Swallow et al, 2007)

Kenya's formal water resource management institutions have been radically transformed with the passage and implementation of the Water Act of 2002. Until 2002, the focus of water management was on the provision of water for domestic and productive uses, but the increasing concerns about water scarcity, low coverage of water services and declining water quality led to a new water policy (Swallow et al, 2007) Under that act, water resource management and water allocation is the responsibility of the Water Resources Management Authority (WRMA), while regulation of water services providers is the responsibility of the Water Services Regulatory Board (WSRB). The Water act 2002 provides for the management of water as a resource within the context of catchments defined by WRMA which formulates strategies for the management, use, development, conservation, protection and control of water resources within each catchment area. Several community groups – committees - have been established over the last 15 years with support from the Ministry of Agriculture, a national authority (Swallow et al, 2007).

4. Experimental Design

One of the objectives of the experimental games was to identify the factors driving cooperation or collective action at the behavioral and institutional levels. Water and watershed management have some features that impose additional difficulties to collective action such as the rival nature of the resource and the asymmetries in access to the resource between upstream and downstream users. In order to include the provision and appropriation aspects of water management, a new experimental design called the *Irrigation Game* (Cardenas et.al. 2008) was used in the field experiments run in Colombia and Kenya watersheds, complemented by the well known public goods or VCM (*Voluntary Contribution Mechanism*) game.

In the ***Voluntary Contribution Mechanism*** **(VCM)**[7] players can contribute the tokens which they receive at the beginning of the game towards the provisions of a public good. Tokens kept have a private value while tokens invested in the public or group account generate a "public good" return by transferring income to the contributor and the rest of the players. For this to be a public goods problem or a collective action dilemma the returns from the tokens kept must

[7] See Ledyard (1995) for a survey of this design and its main findings mostly from lab experiments conducted with students.

induce a greater value than investing the tokens in the group account and therefore inducing Nash equilibrium where nobody should contribute to the group account. However, if all players contribute to the group account the group achieves the socially optimum outcome. To make this quite simple and applicable in the field, in our design participants are assigned to groups of five people who play for twenty rounds. At the beginning of each round, each player receives an endowment of 25 tokens that can be contributed to the public fund or kept in a private account. The total contributions to the public fund by the five players is doubled and immediately distributed in equal shares to all players of the group at the end of each round. The only information given to the players in each round is the total contributions by the group and the amount each receives from the public fund, which is then added by each player to her tokens not contributed. Clearly, a group is better off by investing all 125 tokens which are doubled and thus yield 250 tokens to be distributed to the five players. However, any of the players will have an incentive to free-ride on the contributions by the others, keep her endowed tokens and still receive 1/5 of the tokens produced by the public fund. Since this is the Nash (and dominant) strategy, the equilibrium of the game at any round would be that each player keeps her 25 tokens for a social efficiency of 50% (125 tokens of the 250 possible). The individual and group contributions to the public good are therefore a measure of the willingness to cooperate by the group members. The capacity of a group to sustain levels of cooperation throughout the rounds is also a measure of the cooperativeness of a group.

The ***Irrigation Game*** introduces the appropriators' differential access to the resource because of location between head-enders (upstream residents) and tail-enders (downstream residents) in the system. The first part of the game is similar to the VCM design: players can contribute any portion of their endowment of 10 tokens to a public good. Tokens not contributed are kept in a private account which yields private returns. The public good is a project to maintain water canals or water springs (watershed function) so the amount of available water depends on the total contribution according to a monotonic function of tokens contributed (Figure 1) following a typical sigmoid production function. However, the production function of the public good will maintain in average the same proportion as in the VCM game before, that is, if the group contributes the full endowment, the water produced will double.

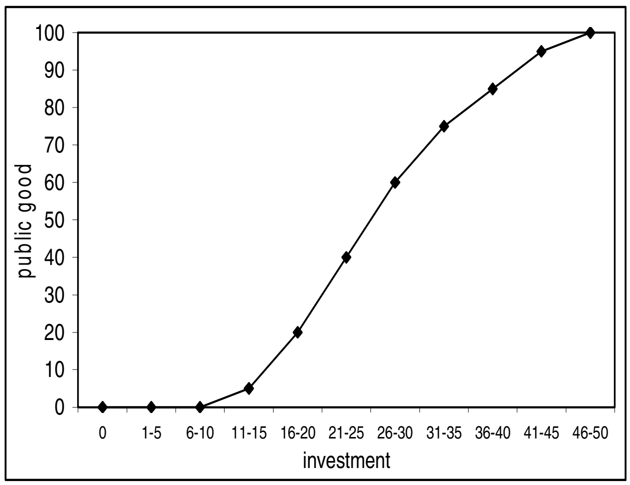

Figure 1. Water Production Function

The water produced by the group as a result of their combined "provision" decisions is then distributed in the next stage of the game through the "appropriation" decisions. Each player is told how much water is available and she then decides how much water to extract. Decisions are taken in order according to the player's location in the watershed starting with player A, the furthest upstream, and ending with player E, the further downstream. The assignment of the locations is made randomly among the five players at the start of the game and remained the same throughout the rounds. In brief, player A has access to all the water produced in phase 2. The water left by A is then offered to B who then decides how much to extract and how much to leave for the rest downstream and so on, until we get to player E. The only information given to the players is how much water is available (left by those upstream), so except for player B, no players have information about how much was extracted by the others.[8]

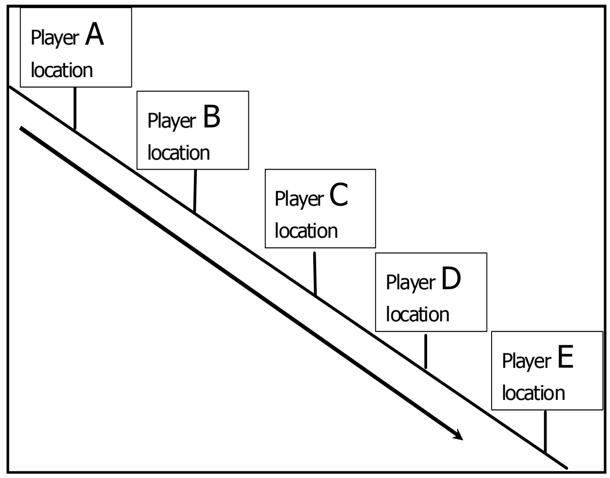

Figure 2. Players Location

After the first ten rounds of baseline treatment, rules changed for some groups, and this change is announced aloud to the players. Some groups of the VCM game were permitted to communicate, and other groups continued playing under the baseline conditions. The second stage of the *Irrigation Game* had four treatments: baseline, communication, high penalty and low penalty.

The **face-to-face communication** treatment allowed players to communicate with each other in the group before making her private decision in each round. In the **penalty treatments,** a regulation is imposed on how much water can be extracted by each player—20% of the water produced—with a positive probability (p=1/6) that players' extraction decisions will be monitored after each round. All the players were to be inspected if a dice rolled in front of them turned up six.. Players caught extracting more than their fair share were fined. In the high-

[8] This paper focuses on the problem of cooperation in contribution a public good under symmetric and asymmetric conditions (VCM and irrigation). Analysis of the appropriation decisions themselves can be found in Cardenas et.al, 2009.

penalty treatment the fine to be paid was the extra amount taken plus six units of the player's accumulated earnings. In the low-penalty treatment only the amount taken in excess of the one-fifth share was forfeited. As in the baseline, players in the treatment round only know the aggregate outcome of each round but not the individual decisions.

5. Recruitment in the field and sample across watersheds

We recruited actual watersheds inhabitants who in their daily lives face water provision and appropriation decisions such as those simulated in the games. A total 500 inhabitants across the four watersheds participated in the two games. The distribution of the players between the games and watersheds along with the total number of observations are shown in table 1[9].

Game	VOLUNTARY CONTRIBUTION				IRRIGATION GAME				
Country	**Kenya**	**Colombia**		**Total**	**Kenya**		**Colombia**		**Total**
Watershed	Kapchorean River	Fuquene Lake	Coello River		Awach River	Kapchorean River	Fuquene Lake	Coello River	
Session	12	25	13	50	12	12	27	20	71
Total players in sessions	60	125	65	250	60	60	135	100	355
Total Observations	1200	2500	1300	5000	1200	1200	2700	2000	7100

Table 1. Summary of the sessions

Tables 2 and 3 show some of the socio-demographic characteristics of the participants in the experiments. There is considerable variation in education level, household size, access to utilities and main farm use among Colombian and Kenyan participants. Although VCM participants in Coello and Kapchorean have similar levels of education, *Irrigation Game* participants in Colombian watersheds were more educated than the Kenyan participants.

[9] Because of constraints with time and funding we could not run the VCM games in the second watershed in Kenya (Awach river).

Country	Kenya	Colombia	
Watershed	Kapchorean River	Fuquene Lake	Coello River
Education (years)	4.71	6.91***	4.76
Female (%)	18.33***	54.84***	69.23***
Age (years)	43.52**	35.46***	41.58**
Time living in that place	29.36***	25.46	25.63
Household size (people)	7.30***	4.83	4.93
Watershed location (%)			
Upstream	50.00	12.00	23.08
Middlestream	50.00	36.00	30.77
Downstream	0.00	52.00	46.15
Main water source (%)			
Piped water	0.00	62.30	28.13
Natural source (spring, river)	96.67	27.87	70.31
Other	3.33	9.84	1.56
Utilities access (%)			
Piped water	3.33	76.47	61.54
Electricity	1.67	94.96	84.62
Main farm use (%)	0.00		
Agriculture	100	36.75	55.74
Livestock	0.00	31.62	1.64
Housing	0.00	31.62	42.62
N	60	125	65

***1% t test significance level **5% t test significance level

Table 2. Socio-demographic characteristics VCM participants

Participation of women in the games was lower in the Kenyan watersheds than in the Colombian watersheds; in both Colombian watersheds more than half of the participants were females. Access to utilities is higher in the Colombian watersheds, especially in Fuquene. Piped water access was very low in both the Awach and Kapchorean watersheds It was higher for Fuquene and Coello watersheds, nonetheless many of Coello participants used natural water sources instead of piped water as their main water source. Since the demographic characteristics of the sample are unbalanced, it is necessary to control for these variables in the regressions.

Country	**Kenya**		**Colombia**	
Watershed	Awach River	Kapchorean River	Fuquene Lake	Coello River
Education (years)	5.20***	4.23***	6.75**	6.42**
Female (%)	38.33***	23.33***	53.73***	63.27***
Age (years)	46.01***	38.12***	34.85***	42.05***
Time living in that place	38.16***	25.22	26.07	29.23***
Household size (people)	6.22^{+}	6.25^{+}	5.16^{+}	5.14^{+}
Watershed location (%)				
Upstream	50.00	50.00	29.63	35.00
Middlestream	0.00	50.00	37.04	30.00
Downstream	50.00	0.00	33.33	35.00
Main water source (%)				
Piped water	3.33	0.00	61.54	41.84
Natural source (spring, river)	91.67	91.66	20	56.12
Other	5.00	8.33	18.46	2.04
Utilities access (%)				
Piped water	5.00	0.00	69.7	61.00
Electricity	0.00	0.00	94.7	83.00
Main farm use (%)				
Agriculture	85.00	98.33	26.32	36.08
Livestock	5.00	0.00	32.33	7.22
Housing	6.67	1.67	40.6	50.52
N	60	60	135	100

***1% t test significance level **5% t test significance level
$^{+}$ the results of watersheds of the same country are not statistically significant but it is different between countries

Table 3. Socio-demographic Characteristics of *Irrigation Game* participants

The information about age and time living in the communities is similar for both countries. Household size is larger in Kenya, and the agricultural land use shows a pattern of higher dependence on crop agriculture in Kenya compared to Colombia, with 100% and 85% of Kenyan participants reporting cropping as principal land use for VCM and *Irrigation Game*, respectively. In contrast, the percentage of Coello and Fuquene participants who reported housing as the main farm use is close to 40% of the cases, which probably means that these people have alternative jobs outside of agriculture. Off-farm employment and income are known to be important in all communities though more so in Kenya than Colombia (Johnson et al 2008; Teyie et al, 2006), however the agricultural land variable was used in this analysis to capture both importance of agriculture and attitude towards land use in watershed context.

6. Games Data and Results

Let us recall that the social optimum or maximum social efficiency for the VCM game is obtained when all 125 tokens are contributed to the public good, generating 250 tokens in benefits for the group. In the *Irrigation Game* this is achieved when all 50 tokens of the endowment are contributed producing 100 units of water[10]. The Nash Equilibrium for both games is zero contribution resulting in a suboptimal result of 50% of the maximum social efficiency possible in either game.

The overall results replicate two patterns observed in previous experimental studies. The individual behavior for the baseline treatments and for the first ten rounds of the entire sample does not confirm the hypothesis from the self-oriented free-riding prediction from non-cooperative game theory. The fraction of decisions that fall within the category of Nash strategy was of only 3% for all ten rounds, and of 5.6% for the round 10 of the sample for the VCM game, and of 6.2% and 7.3% respectively for the irrigation game. The results also support the finding that face-to-face communication, although not binding and considered "cheap talk", does increase the levels of cooperation and social efficiency, although with different results across

[10] To be more precise (See Figure 1), in the irrigation game a group could maximize earnings by contributing 46 tokens and still produce 100 units of water, for a total of 104 units of group earnings.

watersheds. In average, groups that were allowed to communicate achieved substantial improvements on their provision decisions even under conditions of asymmetric appropriation. We will first present the overall patterns of the results in graphical form and then proceed to the econometric analysis of the data.

6.1. Voluntary Contribution Game (VCM)

The following graphs compare the results of average amounts contributed by the players round by round, expressed as percentages of the initial endowments. In the baseline treatments the players' environment of incentives and rules were the same during all 20 rounds while in the communication treatment the players were allowed to talk to each other after round 10 and in every subsequent round. The regulation treatments also had the first ten rounds under the baseline treatment and then from round 11 they faced the regulatory scheme already described.

The players contributed on average 40.6% of their endowments (10.14 tokens) in the ten initial rounds. Groups that continue playing in the baseline treatment contributed on average 9.1 tokens, 36.4% of their endowments in the following ten rounds. Contributions jumped to 58.7% of the endowment when players could communicate with other players in the group. However, communication is not equally effective in all three watersheds.

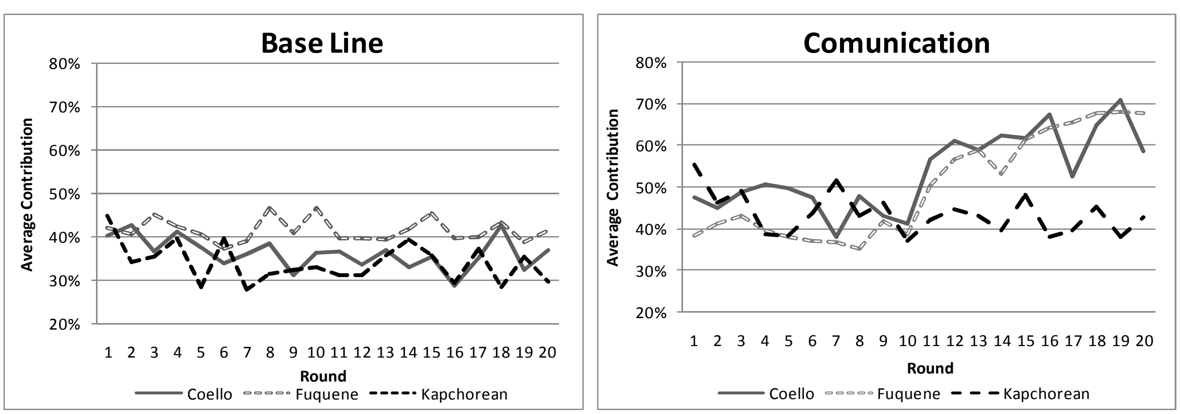

Figure 3. Voluntary Contribution Mechanism average results

While the average contribution for communication groups increased from 11.47 to 15.37 tokens in the Coello watershed and reached 15.34 tokens in Fuquene, contributions did not increase as a consecuence of communication in the Kapchorean watershed, remaining at 10.53 tokens which was very close to contribution level before comunication was permitted. The following chart summarizes these results:

Country	**Kenya**	**Colombia**	
Watershed	Kapchorean River	Fuquene Lake	Coello River
Baseline - rounds 1-10	8.67	10.54	9.36
Baseline - rounds 11-20	8.33	10.22	8.77
Communication - rounds 1-10	11.23	9.74	11.48
Communication - rounds 11-20	10.53	15.34***	15.37***

***1% level of significance for the difference between stage 1 (rounds 1-10) and stage 2 (rounds 11-20) T-Test and the Mann-Whitney RankSum Test.

Table 4. Summary of average contribution of the VCM

The effectiveness of communication depends on the possibility that players craft agreements to cooperate. While 75% of Coello participants in communication treatment and 75.3% of Fuquene participants believed that the group got an agreement, these result were lower for Kapchorean participants where just 33% of the participants answered affirmatively this question in a post-game survey.

6.2. Irrigation Game

The individual contribution was on average 4.82 tokens for the *irrigation game*, 48.2% of players' endowment, for the ten initial rounds[11]. For the second stage of the game, the groups

[11] However, these results varied according to the players' location along the water system. While contribution of players A was in average 53.17%, contribution of player E was 42.76%. The construction of both games implies that while the opportunity cost of a token non-invested in VMC is the same for all players, the opportunity cost for the *Irrigation Game* is asymmetric among players, given the different uncertainty that each player has over his own investment. For instance, player A knows that he will have total control over the initial amount of water produced while player E depends entirely on the extraction by all other players upstream.

that continued playing with baseline conditions obtained an average contribution of 4.71 tokens (47.1% of their endowment), while the groups that communicated reached a contribution of 5.9 tokens on average (59%). The penalty treatments obtained an average contribution of 4.83 (48.3%) for high penalty and 3.96 (39.6%) for the low penalty.

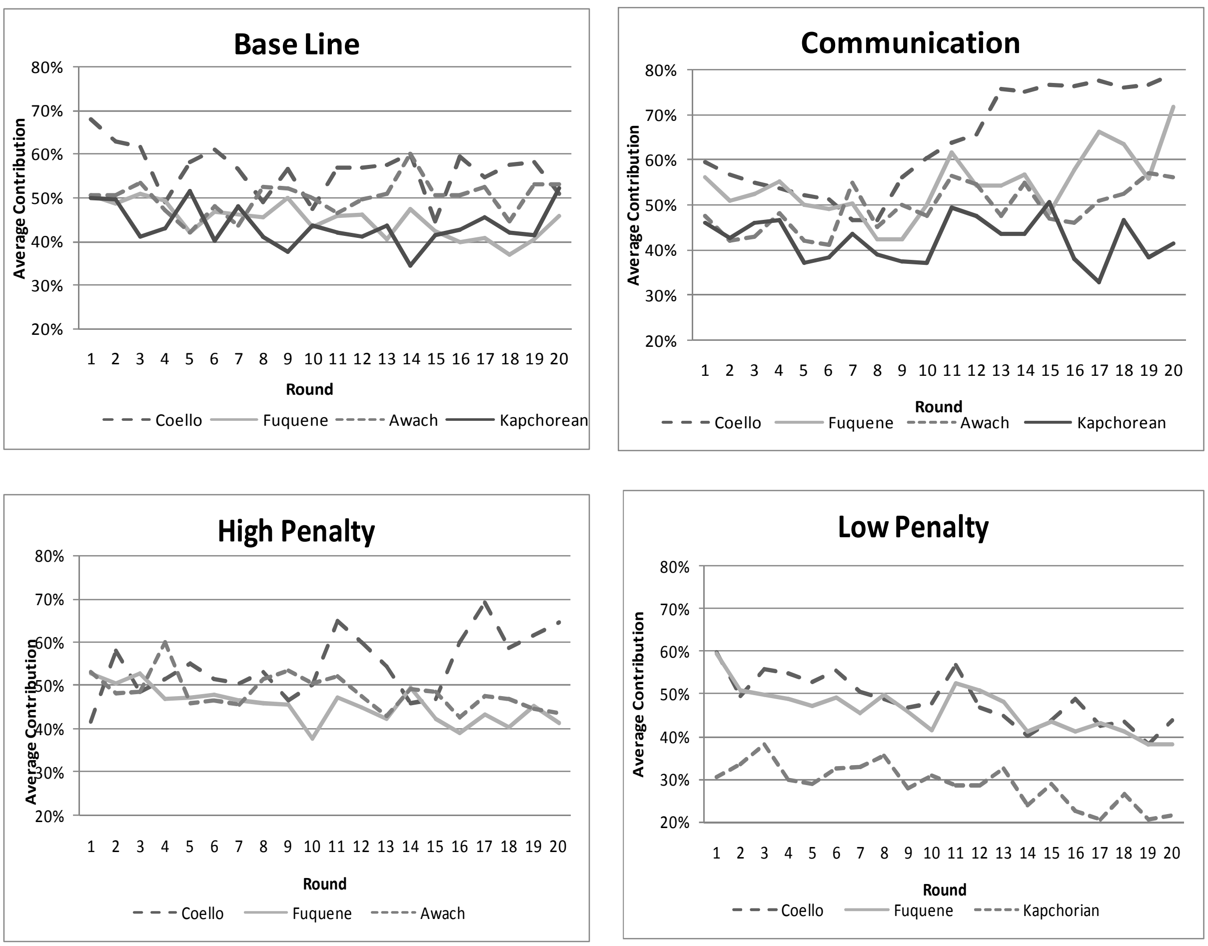

Figure 4. Irrigation Game (contributions stage)

Communication was the most effective treatment but the level of effectiveness depended on the watershed, just as in the VCM game. Once again the Coello watershed inhabitants achieved the best results with an average contribution of 7.42 tokens while Kapchorean watershed participants did not change on contributions despite the change in game conditions. These results appear to be related to the effectiveness of the communication that took place before each round. According to the post-game survey results, 88% of Coello participants believed that they reached an agreement during the conversation period compared to only 54.3% for Fuquene, 35% for Kapchorean watersheds and 30% for Awach.

These results suggest that the problem was not in honoring the agreements, but rather that they failed to craft one.

In contrast to the face-to-face communication treatment, the imposition of an external regulation that was imperfectly enforced did not improve social efficiency. In fact our participants decreased their contributions under the regulations, especially in the case of the low fine. Some explanations for this behavior such the crowding-out of cooperative behaviour have been explored in other works (Cardenas et.al, 2000; Bowles, 2008). The basic argument is that the intrinsic motivations to cooperate with others can be crowded out when explicit monetary incentives are introduced, turning a group-oriented task into a game between each individual player and the external regulator with imperfect monitoring and sanctioning capacities.

Country	**Kenya**		**Colombia**	
Watershed	Awach	Kapchorean	Fuquene	Coello
Baseline - rounds 1-10	4.89	4.45	4.73	5.7
Baseline - rounds 11-20	5.11	4.26	4.26**	5.57
Communication - rounds 1-10	4.61**	4.13	4.98	5.38
Communication - rounds 11-20	5.23**	4.32	5.9***	7.42***
High Penalty - rounds 1-10	5.03	---	4.73	5.06
High Penalty - rounds 11-20	4.65	---	4.35**	5.86***
Low Penalty - rounds 1-10	---	3.17	4.86	5.21
Low Penalty - rounds 11-20	---	2.56*	4.37**	4.48***

***1%, **5%; *10%, level of significance for the difference between stage 1 (rounds 1-10) and stage 2 (rounds 11-20) T-test and Mann Whitney Ranksum test

Table 5. Summary of average contribution of the *Irrigation Game*

7. Regression Results

The decisions that players make during the experiments depend on the information available to them at the time of the game. Three distinct types or layers of information are hypothesized to be relevant: the material incentives and the dynamics of the game, including the payoffs from the contributions and the benefits from the public fund, as well as the expected costs from the sanctions against the benefits from violating the regulations; the composition of the group of players; and the individual characteristics each player. The dynamics of the game include the fact that the same players meet in future rounds so they can learn and construct a reputation. These dynamics can be crucial to cooperation: *'the information that can be gathered about past rounds and the probability of future ones with the same players creates the conditions that are conductive for cooperation through reciprocity, including retaliation towards non-cooperators as a group selection mechanism'* (Cardenas and Ostrom, 2004).

The group-context layer is based on the notion that players' decisions are also influenced by the recognition of *who the other players are in the transaction.* This knowledge can influence reputation, reciprocity and trust construction in the game as players allow their prior knowledge (i.e. prior to the experiment) or pre-conceptions of the other players to influence their decisions. Finally, the individual identity layer consists of information about personal characteristics of players that can affect strategies and subjective payoffs (the non-economic value of a payoff has to a player due to moral values and internalized norms). These characteristics can include personal values as well as socio economic and demographic aspects of participants (Cardenas and Ostrom, 2004).

In order to identify how these different sets of factors influence collective action in these four watersheds, we use a regression analysis in which we attempt to explain the individual levels of cooperation in each round as a function of vectors of these three types of variables: game variables, group level variables, and individual variables. The individual data were obtained through a survey that the players filled out at the end of the game and include information about basic socio-demographic variables, as well as personal opinion and perceptions about community cooperation and regulation preferences. The cooperation or contribution variable is defined as the percentage of tokens contributed from her endowment, by each player in each round. The game structure variables are the round, the treatment (baseline and communication for the VCM and the penalty treatments for the *Irrigation Game*), and the other four players' contribution in the previous round. We include controls for the group-context variables such as dummy variables for the watersheds and for the particular session. Because we are interested in the particular role that women may play in the management of water resources in rural areas, we also tested the gender role by controlling for the gender of the player and for the gender composition of the group by calculating an index of gender distance among players in the group[12]. In table 6 we present the definition of the variables we use for the regression analysis and in table 7 their descriptive statistics.

[12] The gender distance variable was calculated as abs (SEX-(SEXSUM8-SEX)/5)) where SEX=1 for women.

Variable	Definition
Contribution	Percentage of tokens contributed
Communication	A dummy for communication treatment
High Penalty	A dummy for high penalty treatment (*Irrigation Game* only)
Low Penalty	A dummy for low penalty treatment (*Irrigation Game* only)
Others contribution lagged	Percentage of other four players contribution in the previous round
Sexdistance	Gender distance between one player and the rest of the group.
Age	Age of the player (years)
Gender	A dummy that takes a value of one if woman
Education level	Level of education of the participants (years)
Time in the community	Time living in the community (years)
Household size	Number of people that live together in the same house
Perception about self-governance	A dummy that takes a value of one if the person believes that group should reach an agreement
Perception about external regulation	A dummy that takes a value of one if the person believes that the group need external rules or regulations
Participation in community activities	A dummy that takes the value of 1 if the person participates in voluntary community activities for water conservation
Community cooperation	Perception about neighbors who cooperate in community activities per every 10.

Table 6. Definition of variables

Overall, we have more than 5,000 observations for the VCM game and 7,000 for the irrigation game from the 50 and 71 sessions respectively. The variability of the socioeconomic variables gives us the possibility to conduct regression analysis and get conclusions about the average behavior. Besides, the mean results of these variables are similar for both games which permit us to compare results between games.

	Voluntary Contribution Mechanism					Irrigation Game				
Variable	Obs	Mean	Std. Dev	Min	Max	Obs	Mean	Std. Dev	Min	Max
Contribution	5000	0.45	0.29	0	1	7085	0.48	0.29	0	1
Communication	5000	0.31	0.46	0	1	7100	0.15	0.35	0	1
Others contribution lagged	4988	0.45	0.2	0.01	1	7100	0.49	0.17	0	1
Sexdistance	4980	0.38	0.31	0	1	7040	0.41	0.3	0	1
Age	4940	39	15.76	14	90	7060	39.291	15.27	14	88
Gender	4980	0.5	0.5	0	1	7040	0.49	0.5	0	1
Education level	4600	5.83	3.67	0	17	6860	5.97	3.6	0	19
Time in the community	4760	26.47	16.28	0	77	6860	28.85	17.71	1	88
Household size	4600	5.49	2.94	1	22	6760	5.53	2.84	1	20
Perception about self-governance	4860	0.81	0.39	0	1	6900	0.74	0.44	0	1
Perception about external regulation	4900	0.54	0.5	0	1	6940	0.51	0.5	0	1
Participation in community activities	49200	0.64	0.48	0	1	7060	0.62	0.48	0	1
Community cooperation	4600	5.23	2.84	1	10	6920	5.42	2.72	0	10

Table 7. Summary Statistics *Voluntary Contribution Mechanism* and *Irrigation Game*

Table 8 and 9 show the regression results for the two games, where the dependent variable is the individual contribution as a fraction of the individual endowment. In both games contributions are equivalent in terms of the monetary value of every token not invested in the public fund. However, we must remember that the externalities flow symmetrically across the five players in the VCM game whereas the flow in one direction from upstream to downstream players in the irrigation game.

As we can see, our estimated models explain a substantial amount of the variation in the individual contributions, near 1/3 of variation in contribution for VCM and 1/4 for *Irrigation Game*.

We use the same regression strategy for both games. The first model estimated is a pooled model (Col 1) where we regress the contribution level as a percentage of total number of tokens available to the player on the variables previously mentioned. The second model (Col 2) includes watershed dummies (the omitted dummy corresponds to the Kapchorean watershed for both games). Finally, we estimate the regression separately for each of the four watersheds.

For all cases the round effect is rather small suggesting that for these games the deterioration of cooperation usually observed in VCM laboratory experiments does is not confirmed here. In the case of the irrigation game we do observe a consistent negative and significant effect although again the coefficient size is not very large. Our conjecture is that the nature of the sequential problem in the irrigation game does trigger stronger reactions than in the VCM case.

For both games we observe the important effect of the communication treatment in increasing contributions for all estimated models, although we find a stronger effect for Colombian watersheds compared to Kenyan watersheds as can be observed in the size of the estimated coefficients. As mentioned in section 6, when asking the participants at the exit of the game if they perceived that the group had achieved an agreement during the communication sessions, a much larger fraction of players reported so for the Colombian watersheds than for the Kenyan cases.

The introduction of high and low penalties, in the case of the *Irrigation game,* has a rather poor effect on individual contributions than communication, and even if compared to the baseline treatment

Dependent variable:	*Percentage of tokens contributed to the public fund*				
	Pooled	Dummies wtsdh	Coello	Fuquene	Kapchorean
Independent variables	(1)	(2)	(3)	(4)	(5)
Round (learning)	0	0	-0.001	0.003	-0.006
	(0.47)	(0.47)	(0.43)	(2.23)*	(3.35)**
Communication	0.113	0.113	0.138	0.099	-0.001
	(7.63)**	(7.63)**	(5.04)**	(4.92)**	(0.03)
Others contribution lagged (percentage)	0.149	0.149	0.217	0.355	-0.728
	(5.11)**	(5.11)**	(4.09)**	(8.98)**	(10.57)**
Sexdistance	0.054	0.054	0.067	0.107	0.08
	(2.16)*	(2.16)*	(1.64)	(2.64)**	(0.58)
Age	0.002	0.002	-0.001	0.002	0.003
	(5.74)**	(5.74)**	(0.76)	(3.14)**	(2.89)**
Gender	0.008	0.008	0.016	0.01	-0.052
	(0.71)	(0.71)	(0.71)	(0.56)	(0.67)
Education level	0.005	0.005	0.001	0.004	0.007
	(2.54)*	(2.54)*	(0.19)	(1.6)	(1.74)$^{+}$
Time in the community	-0.001	-0.001	-0.001	0	-0.006
	(2.99)**	(2.99)**	(2.67)**	(0.96)	(3.79)**
Household size	0.015	0.015	-0.013	-0.005	0.024
	(7.46)**	(7.46)**	(2.33)*	(1.44)	(7.23)**
Perception about self-governance	-0.011	-0.011	0.065	0.073	-0.168
	(0.84)	(0.84)	(1.84)$^{+}$	(3.579)**	(5.21)**
Perception about external regulation	0.011	0.011	0.02	-0.031	0.067
	(1.09)	(1.09)	(1.06)	(2.36)*	(2.84)**
Participation in community activities	-0.027	-0.027	0.024	-0.048	0.008
	(2.51)*	(2.51)*	(1.21)	(3.34)*	(0.34)
Community cooperation	-0.009	-0.009	-0.015	0.001	-0.028
	(4.54)**	(4.54)**	(2.49)*	(0.44)	(5.47)**
Coello (dummy)		0.275			
		(6.00)**			
Fuquene (dummy)		-0.054			
		(1.14)			

Table 8. Fixed-effects OLS estimation of contribution decisions *Voluntary Contribution Mechanism*

While contributions by other players in the previous round had a positive effect in the VCM, it had a negative effect on contribution in the *Irrigation Game*. This contradictory result may be due to the fact that because of the asymmetries in appropriation, players in the *Irrigation Game* are less able to perceive the benefits of increased overall contributions. However, the negative effect is stronger for the Kenyan basins that for Colombian basins. For the *Irrigation Game*, the game-location has a positive and significant effect, i.e.players located in a higher position contribute higher percentages of their endowment. This can be explained from the very construction of the game: the higher you are in the irrigation system the more control you have over the proceeds of your own contribution. It is true that in the Nash equilibrium all players, including A should invest no tokens in the public fund. However, any other positive contribution should induce player A to invest more and therefore increase her returns on her own investment given that she gets to extract first.

Dependent variable:	*Percentage of tokens contributed to the public fund*				
	Pooled	Dummies wtsdh	Coello	Fuquene	Awach
Independent variables	(1)	(2)	(3)	(4)	(5)
Round (learning)	-0.004	-0.004	-0.003	-0.006	0
	(5.11)**	(5.11)**	(1.70)$^{+}$	(4.46)**	(0.29)
Communication	0.147	0.147	0.234	0.137	0.067
	(9.71)**	(9.71)**	(8.16)**	(5.53)**	(2.14)*
High Fine	0.028	0.028	0.093	0.018	-0.047
	(1.72)$^{+}$	(1.72)$^{+}$	(2.72)**	(0.8)	(1.5)
Low Fine	-0.028	-0.028	-0.051	0.019	
	(1.83)$^{+}$	(1.83)$^{+}$	(1.91)$^{+}$	(0.8)	
Location along the water system	0.02	0.02	0.022	0.02	0.11
	(9.02)**	(9.02)**	(5.01)**	(5.61)**	(2.06)*
Others contribution lagged (percentage)	-0.15	-0.15	-0.014	-0.08	-0.207
	(5.37)**	(5.37)**	(0.28)	(0.18)	(3.37)**
Sexdistance	-0.142	-0.142	-0.288	0.91	-0.343
	(7.36)**	(7.36)**	(6.82)**	(3.22)**	(8.72)**
Age	0.003	0.003	0.02	0.005	-0.004
	(8.71)**	(8.71)**	(2.25)*	(9.26)**	(0.37)
Gender	-0.011	-0.011	0.024	0.034	0.104
	(1.32)	(1.32)	(1.64)	(2.49)*	(5.15)*
Education level	0	0	0.005	0.003	-0.014
	(0.37)	(0.37)	(2.44)*	(1.71)$^{+}$	(4.31)**
Time in the community	0	0	0	-0.001	0
	(1.49)	(1.49)	(0.55)	(2.59)**	(0.48)
Household size	0.006	0.006	0.004	0.013	0.012
	(4.29)**	(4.29)**	(1.22)	(5.31)**	(3.983)**
Perception about self-governance	0.066	0.066	0.071	0.083	0.023
	(6.98)**	(6.98)**	(3.72)**	(5.47)**	(1.16)
Perception about external regulation	-0.037	-0.037	-0.04	-0.061	0.052
	(4.62)**	(4.62)**	(2.69)**	(4.47)**	(2.69)**
Participation in community activities	-0.012	-0.012	-0.016	0.04	-0.006

Table 9. Fixed-effects OLS estimation of contribution decisions *Irrigation Game*

While the variable that measures the gender distance between the player and the rest of the group has a slightly positive effect in the VCM but its effect is negative and stronger for the Irrigation Game. This index is greater for cases where there are less people of the same gender in the group. The negative effect in the case of the irrigation game may be explained by two non mutually exclusive reasons. One, the framing of the game makes clear that this is a game about water and women in general are responsible for suffering the consequences of poor supply of water in the villages (cooking, animal care and bearing children are highly dependent on water). Greater gender homogeneity leads to larger contributions. The second reason may be Tajfel's ingroup/outgroup effect, in this case based on gender although this should also apply for the VCM where we do not find the effect as clear.

Given the heterogeneity of the demographic composition of the groups we have included in the regressions other controls that can be checked in tables 8 and 9. The perception variables about regulations both have significant effects for the *Irrigation Game*. If people believe that the group should reach an agreement their contribution is higher while if they believe that they need external regulation, their contributions are less. This helps explain the success of the face-to-face communication institution against the external regulations tested in the experiment. As the selection of sessions to the different treatments was random, we should expect a random fraction of people that believe in the group agreements and when exposed to such possibility, exercise it.
The variable measuring individuals' perceptions of actual levels of cooperation and participation in group activities in their communities has unconclusive results. It has a negative effect on contributions in the VCM and no effect in the *Irrigation Game* but with different signs in the watershed models.

8. Discussion

These two games offer some valuable contrasts that can enrich our understanding of cooperation in watershed management.

One of the main differences among games relates to the contrary signs in the effects of the contributions by the others in the previous round. While it has a positive effect in the VCM, it has a negative effect in the *Irrigation Game* possibly indicating that the irrigation game does not build a setting for the build up of positive reciprocity. As suggested above, one explanation for this is that because of the asymmetries in appropriation, increases in overall contributions may not translate into increases in individual level water allocations. In fact, over time upstream players may even increase their extraction levels as the size of the pot grows and they realize that they can get away with it. The implication for policy is that groups facing this structure of incentives will likely need additional mechanisms to maintain collective action over time. On the other hand, the stronger negative effect is observed for the two Kenyan watersheds and weaker for the Colombian ones. It is worth noting that in the Kapchorean watershed there was negative effect of contributions in previous rounds even in the VCM game. Remember, face-to-face communication had the poorest results in the Kenyan watersheds, and particularly lower for the Kapchorean basin (See Table 5). There are some lights in the demographics of our Kapchorean sample, shown in Table 3. First, they had the lowest education level which we have seen has a positive effect on contributions. Likewise, they had the larger household size which also seems to affect negatively contributions. Finally, the Kenyan samples in general and the Kapchorean in particular show very high percentages of households who get their water from natural sources, have no access to piped water or electricity and are dedicated mostly to agriculture. This all may suggest a precarious existence of water management infrastriucture and formal institutions, although we do not have detailed information about informal institutions in place by watershed.

The most powerful treatment to increase cooperation is communication, but with differences across watersheds. The Kenyan watersheds in particular obtained lower benefits from communication. As mentioned earlier this seems to be because groups failed to reach consensus during the communication period.

Although some Kenyan participants try to start a conversation that could lead to an agreement, these efforts usually did not succeed. For example, some groups' conversation went like this: "*The first people to play get more points. I was getting zero so many times that I will reduce my contribution"; "It is good to extracted water and remember others"; "Some people take too much water but contribute less"; "Some members take too much, consider next consumer"; "We should contribute more to get more water"*

These results can be explained by differences in the cultural and biophysical contexts of the two countries and among watersheds. First of all, while water scarcity is an important issue in both Colombian watersheds, this perception can be different in Kenyan basins where ethnic customs – mainly Luo – holds that water access should be freely available, particularly for basic household uses. According to (Swallow et al, 2007), *"one possible drawback of the Luo custom for land and water governance is that there is a relatively little incentive for private individuals or small groups to invest in protecting existing water sources. This has particular impacts on women, who are responsible for provisioning the household with water and for providing health care within the household"* (Swallow et al, 2007). 25% of *Irrigation* game participants were Luo, 34% Kisii, 16.7% Kalenjin, 1.69% Kipsigis and 10.79 Kikuyu[13]. VCM did not have Luo participants because it was played in the upper parts of the basin; however the custom of free access to water

[13] The ethnic distribution for the Irrigation Game by watershed is: 50%Luo, 31.64 Kalenjjn and 18.36% Kipsigis, for Awach watershed and 68,42% Kisii, 21.65% Kikuyu and 9.93% other ethnic groups.

is shared by the other ethnic groups ,as reflect in the Kalenjin proverb *"Even the hyena has right to water"* (Onyango et al, 2007)

Perceptions of water scarcity also differ across communities, reflecting both biophysical realities and cultural influences about how water should be distributed. While 50.7% and 48% of Coello and Fuquene watersheds *Irrigation Game* participants respectively consider that in the future people should consume less water, these percentages are 28% and 25.2% for Awach and Kapchorean watersheds[14].

These perception may also be influenced by past community organization and education work in the watersheds. While NGOs mobilization is lower in Fuquene, community organization around water is important in some places of the watershed, especially related to piped water access. The organizational process in Coello around environment protection has been strong and has emphasized the upstream-downstream linkages among people. Nyando basin has an important presence of community groups but there has been relatively little success in initiating and sustaining local social organization around water management (World Agroforestry Center, 2006). Explanations for this include gender roles that separate responsibility for household water provision and land tenure arrangements that restrict group investment on private land (ibid). The effect of different gender roles around water provision could be reflected during the games in the negative sign of the gender distance variable for the *Irrigation Game* and no for the *VCM*.

These results suggest two implications for policy. The first is that while communication is an effective tool for enhancing collective action, it can only work through a series of steps that start from the understanding of the mapping of actions into outcomes in the social dilemma to the crafting of the agreements and the trial and error of the cycle of trust, reputation and reciprocity

[14] These results are different for the *VCM* where 25% of Coello participants, 38% of Fuquene participants and 25% of Kapchorean participants believe that in the future people should consume less water.

(Cardenas, Ahn and Ostrom, 2004). Allowing groups to talk for a fixed amount of time does not necessarily mean that the process will happen. Any intervention incorporating communication should pay attention to the factors that enhance and inhibit communication in a particular context. Second, the institutional and cultural context, including beliefs about how resources should be managed and shared, will have a strong effect on how people make decisions about water management and use. These need to be considered in the formulation of any intervention.

Ironically, achieving the social optimum in the game is not always about encouraging people to act less selfishly and more altruistically. On average the participants in position E in the Watershed Game extracted only 74.4% of the water available to them. Experimentally there was nobody below E so there was no rational reason for them not to take all the remaining water. The importance of leaving water to down stream users was mentioned in some conversations among the players, especially in Coello: *"Player E should leave water in the canal for the people below him"*[15]*, "Why are we leaving water? Let's contribute 10 and extract 20 to have for everybody. No, it is better that each one extract 15 to leave water"; "Now let's contribute 10 and extract 18 to leave something to the next in the watershed"*. However, this result has interesting implications in policy interventions where this altruistic behavior could have important implications in water access.

[15] *"El E debe dejar agua en el canal para los que siguen"; "¿Para que dejamos agua? Aportemos de a 10 y sacamos de a 20 para que quede para todos. No, mejor 15 cada uno para que quede agua"; "Ahora aportemos 10 y sacamos 18 para que quede algo para los que siguen en la cuenca"; "Al último hay que dejarle agua para que deje". ("E should leave wáter in the canal for those that follow"; "Why leave water? Let's contribute 10 and extract 20 each so that there is enough for everyone. No!, let's better do 15 so that there is water left"; let us contribute 10 and extract 18 so that there is something for those that follow in the basin"; "We should leave water for the last one so that he leaves something")*

9. Conclusions

In the experiments presented in this paper, we explore the specific problems of contribution to the public projects under two scenarios, namely when the resource and benefits are distributed evenly and simultaneously among the players, regardless of the contributions that each made to the public fund, and when appropriation stage occurs sequentially starting with those players located in the upstream section of a the water system. Given our sample and the different treatments tested, we were able to derive some conclusions regarding behavior and the effect of certain institutional devices on cooperation in the provision of public goods. Baseline data were collected from each participant to provide additional information about the players and their communities that helps explain their behavior in the games.

There were significant differences across watersheds in terms of their socio-economic and cultural and institutional contexts and these were reflected in the results obtained. The most powerful treatment to increase cooperation was communication, but with differences by watershed. Communication was more beneficial in the Colombian watersheds than in the Kenyan sites, mainly because participants in Colombia were able to communicate more effectively and reach agreements about how to coordinate their behavior to improve the game outcomes. There was no evidence that participants in Kenyan sites were less likely to honor informal agreements once they were made, however they have difficulty getting to craft such agreements as reported by the participants at the end of the games. Interventions designed to use communication as a tool to foster collective action would need to take this into account. Future studies using this game might consider varying the length of the communication period or providing facilitation to see whether this affects groups' ability to reach an agreement.

Another important result was that the sequential structure in the *Irrigation Game* appears to inhibit the development of reciprocity among the players. Past research has shown that reciprocity is key to maintaining collective action. The VCM with its symmetric payoffs did build reciprocity whereas the *Irrigation Game* with its lack of a clear link between the total contributions and the amount received by each player made it difficult for players to get on a virtuous cycle. We have shown that the higher the player is the more she is willing to contribute to the public fund. Just in the baseline, by the end of the stage, players in the las position E were contributing 38% of their endowment while players A were contributing 52%. Through face-to-face communication we observed that such differences practically vanished, and now players were contributing around 66% for the case of the two Colombian basins and around 47% for the case of Kenya.

Collective action in water management requires that individuals overcome their individual incentives to free-ride and be willing to cooperate in the provision dilemma, which usually corresponds to a problem of public goods where cooperation is privately costly but socially efficient. In some cases the public benefits of cooperation can be distributed evenly and simultaneously across the players—examples include a common water source like a pond or spring from which all users extract simultaneously—while in other cases like irrigation schemes or watersheds the benefits are distributed in a sequential manner along the system. In the latter case, head enders or upstream residents have better opportunities to extract the resource while tail enders/downstream inhabitants suffer the greater externalities in terms of water quantity and quality from upstream users' actions.

The particular case of the Andean basin in South America, and most of the mountainous agricultural areas of central and south America present such setting where water use depends on surface sources as opposed to groundwater. Problems of water scarcity in Latin America are not as severe as in some areas of Africa, although the region we conducted our experiments in western Kenya, does not suffer as much from water scarcity as in other regions of the continent.

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