POLICY PROCESSES AND COLLECTIVE ACTION IN WATER REFORMS: THE CASES OF NICARAGUA AND SURINAME
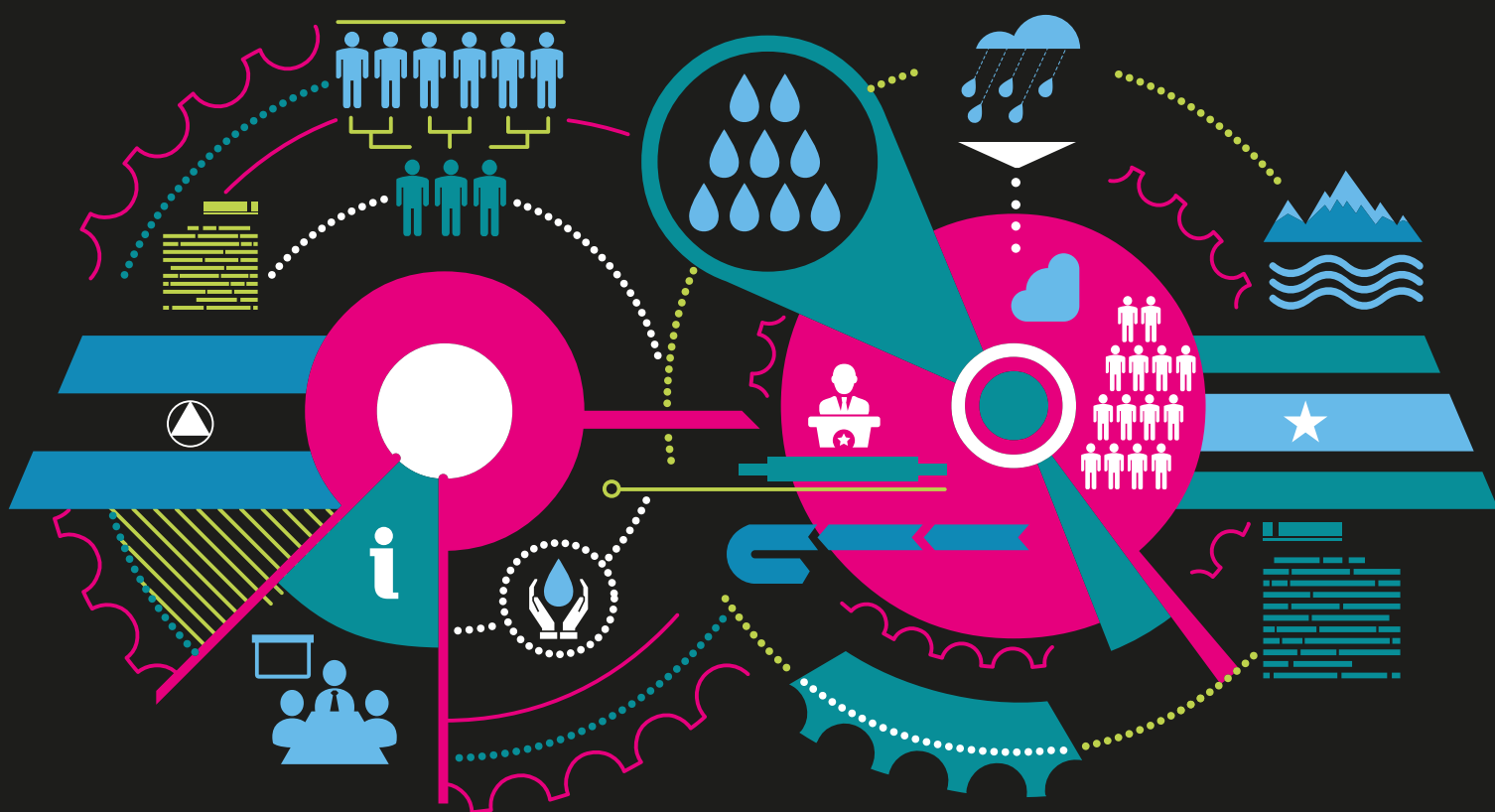
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Policy processes and collective action in water reforms: the cases of Nicaragua and Suriname

TESIS DOCTORAL

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Tribunal nombrado por el Sr. Rector Magfco. de la Universidad Politécnica de Madrid, el día ……… de …………………. de 201…

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EL SECRETARIO

As long as individuals are viewed as prisoners, policy prescriptions will address this metaphor. I would rather address the question of how to enhance the capabilities of those involved to change the constraining rules of the game to lead to outcomes other than remorseless tragedies.

Elinor Ostrom

Governing the commons: The Evolution of Institutions for Collective Action, 1990

A mis padres y a mi hermano

Agradecimientos

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Resumen

Las reformas de agua en países en desarrollo suelen llevarse a cabo junto con cambios institucionales más profundos o, incluso, acompañadas de cambios constitucionales o de régimen político. Por lo tanto, los marcos institucionales adaptados a países gobernados sujetos al estado de derecho pueden no ser apropiados para contextos gobernados fundamentalmente, al menos en sus inicios, por instituciones informales o poco maduras.

Esta tesis toma las reformas de agua como punto de partida y pretende contribuir a la literatura mediante una serie de análisis empíricos tanto del ámbito general como del plano individual o sujeto personal de la política del agua. En el ámbito general, el foco se pone en los factores que explican el fallo de la acción colectiva en dos contextos diferentes: 1) en la implementación de la nueva Ley de Aguas de Nicaragua y 2) en el mantenimiento y revitalización de las instituciones de riego en Surinam. En el plano del individuo, la investigación se centra en las decisiones de los usuarios de los recursos y analiza el papel crítico de las variables sociales para la gestión de los recursos comunes. Para ello, el método de investigación utilizado es mixto, combinando el análisis de entrevistas, encuestas y experimentos.

En el ámbito general, los resultados muestran que las principales barreras para la implementación de la nueva Ley de Aguas de Nicaragua podrían tener su reflejo en el lenguaje de la Ley y, por tanto, en la forma en la que se definen y configuran las instituciones incluidas en dicha Ley. Así, la investigación demuestra que la implementación de políticas no puede ser estudiada o entendida sin tener en cuenta tanto el diseño de la propia política como el marco socio-ecológico en el que se enmarca. El contexto específico de Nicaragua remarca la importancia de considerar tanto las instituciones formales como informales en los procesos de transición política. A pesar de que las reformas de agua requieren plazos largos para su implementación, el hecho de que exista una diferencia entre las reglas tal cual se definen formalmente y las reglas que operan en la realidad merece una mayor consideración en el diseño de políticas basadas fundamentalmente en instituciones formales.

En el ámbito de la conducta individual, el análisis de la acción colectiva ofrece una serie de observaciones empíricas interesantes. En el caso de Nicaragua, los resultados indican que la intensidad de las relaciones sociales, el tipo de agentes dispuestos a proporcionar apoyo social y el nivel de confianza en la comunidad son factores que explican de manera significativa la participación en la comunidad. Sin embargo, el hecho de que la gestión colectiva de riego se produzca, en la mayoría de casos, en torno a lazos familiares sugiere que las variables de capital social críticas se definen en gran medida en la esfera familiar, siendo difícil que se extiendan fuera de estos nexos. El análisis experimental de los resultados de un juego de uso de recurso común y contribución al bien público muestra que las preferencias pro-sociales de

los individuos y la heterogeneidad del grupo en términos de composición por sexo son factores que explican significativamente los resultados y las decisiones de apropiación a lo largo del juego. En términos del diseño de las políticas, es fundamental tener en cuenta las dinámicas de participación y uso de los recursos comunes de manera que los niveles de cooperación puedan mantenerse en el largo plazo, lo cual, como se observa en el caso de Surinam, no es siempre posible.

Finalmente, el caso de Surinam es un ejemplo ilustrativo de los procesos de acción colectiva en economías en transición. El análisis del fallo de la acción colectiva en Surinam muestra que los procesos políticos vinculados al período colonial y de independencia explican en gran medida la falta de claridad en las reglas operacionales y colectivas que gobiernan la gestión de los sistemas de riego y drenaje. Los resultados empíricos sugieren que a pesar de que la acción colectiva para la provisión de los servicios de riego y drenaje estaba bien establecida bajo el régimen colonial, la auto-organización no prosperó en un contexto dependiente del apoyo externo y regido fundamentalmente por reglas diseñadas al nivel competencial del gobierno central. El sistema socio-ecológico que se desarrolló durante la transición post-colonial favoreció, así, la emergencia de comportamientos oportunistas, y posteriormente la inoperancia de los Water Boards (WBs) creados en la época colonial. En este sentido, cualquier intento por revitalizar los WBs y fomentar el desarrollo de la auto-organización de los usuarios necesitará abordar los problemas relacionados con los patrones demográficos, incluyendo la distribución de la tierra, el diseño de instituciones y la falta de confianza en el gobierno, además de las inversiones típicas en infraestructura y sistemas de información hidrológicos. El liderazgo del gobierno, aportando empuje de arriba-abajo, es, además, otro elemento imprescindible en Surinam.

Palabras clave: *instituciones; acción colectiva; reforma de agua; recurso común; bien público; riego; capital social; Nicaragua; Water Boards, Surinam.*

Abstract

Water reforms in developing countries take place along deeper institutional and even constitutional. Therefore, institutional frameworks that might result in positive outcomes in countries governed by the rule of law might not fit in contexts governed mainly by informal or immature institutions.

This thesis takes water reforms as the starting point and aims to contribute to the literature by presenting several conceptual and empirical analyses at both general and individual levels. At the general national level, the focus is on the factors explaining failure of collective action in two different settings: 1) in the implementation of the new Nicaraguan Water Law and 2) in sustaining and revitalizing irrigation institutions in Suriname. At the individual level, the research focuses on the actions of resource users and analyzes the critical role of social variables for common pool resources management. For this purpose, the research presented in this thesis makes use of a mixed-method approach, combining interviews, surveys and experimental methods.

Overall, the results show that major barriers for the implementation of the new Nicaraguan Water Law have its reflection on the language of the Law and, therefore, on the way institutions are defined and configured. In this sense, our study shows that implementation cannot fruitfully be studied and understood without taking into account both the policy design and the social-ecological context in which it is framed. The specific setting of Nicaragua highlights the relevance of considering both formal and informal institutions when promoting policy transitions. Despite the unquestionable fact that water reforms implementation needs long periods of time, there is still a gap between the rules on paper and the rules on the ground that deserves further attention when proposing policy changes on the basis of formal institutions.

At the level of the individual agent, the analysis of collective action provides a number of interesting empirical insights. In the case of Nicaragua, I found that the intensity of social networks, the type of agents willing to provide social support and the level of trust in the community are all significant factors in explaining collective action at community level. However, the fact that most collective irrigation relies on family ties suggests that critical social capital variables might be defined within the family sphere and making it difficult to go beyond it. Experimental research combining a common pool resource and a public good game in Nicaragua shows that individuals' pro-social traits and group heterogeneity in terms of sex composition are significant variables in explaining efficiency outcomes and effort decisions along the game. Thus, with regard to policy design, it is fundamental to consider carefully the dynamics of agents' participation and use of common pool resources, for sustaining cooperation in the long term, which, as seen in the case and Surinam, is not always possible.

The case of Suriname provides a rich setting for the analysis of collective action in transition economies. The analysis of decay of collective irrigation in Suriname shows that the lack of clear operational and collective choice rules appear to be rooted in deeper political processes that date back to the colonial period. The empirical findings suggest that despite collective action for the provision of irrigation and drainage services was well established during the colonial period, self-organization did not flourish in a context governed by colonial state-crafted rules and mostly dependent on external support. The social-ecological system developed during the post-colonial transition process favored the emergence of opportunistic behavior. In this respect, any attempt to revitalize WBs and support self-organization will need to tackle the problems derived from demographic patterns, including land allocation, institutions design and government distrust, in addition to the typical investments in both physical infrastructure and hydrological information systems. The leadership role of the government, acting as a top-down trigger, is another essential element in Suriname.

Table of Contents

List of tables

List of Figures

Acronyms

ACF	Advocacy Coalition Framework
ANA	Nicaraguan National Water Authority
CEIGRAM	Research Centre for the Management of Agricultural and Environmental Risks
CNRH	Nicaraguan National Water Resources Commission
CODA	Nicaraguan Anti-privatization and Water Right Access Alliance
CONAPAS	Nicaraguan Commission on Water and Sanitation
CPC	Citizen Power Councils (Nicaragua)
CPR	Common Pool Resource
DAC	OECD Development Assistance Committee
ENACAL	National Water Supply and Sanitation Company
ENEL	Nicaraguan Electricity Company
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FISE	Nicaraguan Social Investment Fund
FNA	Nicaraguan National Water Fund
GDP	Gross Domestic Product
GNI	Gross National Income
HDI	Human Development Index
IAD	Institutional Analysis and Development framework
IDB	Inter-American Development Bank
IFPRI	International Food Policy Research Institute
INAA	Nicaraguan Institute for Water and Sanitation
INE	Nicaraguan Energy Institute
INETER	Nicaraguan Institute of Territorial Studies
INTA	Nicaraguan Institute of Agricultural Technology
IWRM	Integrated Water Resources Management
MAGFOR	Agriculture and Forestry Ministry (Nicaragua)
MARENA	Environment and Natural Resources Ministry (Nicaragua)
MEM	Energy and Mines Ministry (Nicaragua)
MIFIC	Infrastructure and Trade Ministry (Nicaragua)
MINSA	Health Ministry (Nicaragua)
MS	Multiple Streams Framework
NIE	New Institutional Economics
ODA	Official Development Aid
OECD	Organisation for Economic Co-operation and Development
PET	Punctuated Equilibrium Theory
PG	Public Good
RBO	River Basin Organization
RNDC	Nicaraguan National Consumers Defense Network
SES	Social-Ecological Systems

SML	Mechanized Agriculture Foundation (Wageningen, Suriname)
UN	United Nations
WB	Water Board

1 Introduction

This chapter provides an introduction to the type of problems addressed in the thesis and the research questions that guide the subsequent chapters. Section 1.1 describes the water governance problems that motivate this thesis; section 1.2 formulates the research questions and section 1.3 presents the thesis' outline.

1.1 Problem description

Since the United Nations Water Conference held in 1977 in Mar de Plata, water resources have been a key issue in the development agenda. The lack of stable access to water and land continues to affect a large proportion of people living in developing countries, having a large impact on nutrition, health and human and economic development.

International reports and agreements on water and the environment, such as the Dublin Principles and the Rio Declaration in 1992, have recognized the importance of "creating the enabling environment" for water resources management (UNEP, 2012). While physical water scarcity is a major concern in some regions of the world, economic water scarcity, due to poor governance systems, is identified as the main reason underlying most water crises (CAWMA, 2007). Thus, "creating the enabling environment" requires developing and implementing the required water reforms with the ultimate objective of improving the quality of institutions, as this is recognized essential for the promotion of growth and well-being (Acemoglu *et al.*, 2005).

Since the late 1980s, water reforms have typically been motivated by four major issues. Firstly, the need to improve water resources management in face of an increasing population and economic growth that results in larger water demands, in particular, for home consumption, food and energy production. Secondly, the growing interest in encouraging private participation, decentralization and use of economic mechanisms for water allocation. Thirdly, improving economic efficiency in both water investments and water uses and, fourthly, the adoption of international and regional agreements on water, development and the environment (e.g. Dublin Principles, the Agenda 21 and the Millennium Development Goals). Thus, most water reforms have shifted from a supply-side perspective to incorporate demand-side management mechanisms with the dual objective of increasing water use efficiency while ensuring water resources sustainability (Varela-Ortega, 2007).

Yet, while many developing countries have reformed their water institutions and placed emphasis on integrated water resources management, sustainability and equity, the extent to which these reforms have improved water institutions and, in

turn, water management, remains an open question (van Koppen *et al.*, 2007; Clement, 2010). As argued by Meinzen-Dick (2007), the focus of most of these reforms on a series of institutional arrangements (basically strong government agencies, user organizations and water markets) as panaceas for managing water resources did not take into account key contextual factors. As a result, outcomes of water institutional reforms have been mixed and conditional on a number of factors, such as local rules, definition of property rights and the level of water stress, among others (Araral, 2010a).

Development and implementation of water policies and laws is a complex process because of the multiple interests, stakeholders and problems involved along the policy process. A recently published report on the application of the integrated water resources management approach (UNEP, 2012) shows that 82% out of 134 countries surveyed are reforming their water laws, 79% are modifying their water policies and 65% have already developed integrated water resource management (IWRM) plans. Despite 34% of countries being in an advance stage of implementation, progress has been limited in low and medium Human Development Index (HDI) countries. Some of the factors explaining the low level of implementation are weakness of existing legal frameworks, poor clarity in the formulation of laws and policies, presence of vested interests, limited political engagement, poor coordination and cooperation, insufficient human and/or technical capacity and inadequate participatory processes.

At the core of the IWRM lies downscaling water resources management at the lowest appropriate level, which, in many cases involves the development of decentralization, devolution or deconcentration policies. The rationale for this stands on the argument that natural resources are best managed at the local level as resource users, compared to bureaucrats, have better information and incentives for managing these resources more efficiently (Araral, 2009). Although the academic literature has widely recognized the capacity of users to self-organize and manage resources sustainably (Ostrom, 1990), most decentralization efforts have fallen short to increase power and accountability of local governments and users (Agrawal and Ribot, 1999).

As opposed to top-down approaches, bottom-up approaches reinforce the role of resource users in solving collective action problems. Water resources management in rural communities, including water provision for human consumption and agriculture, shares the type of social dilemmas associated to public goods and common pool resources (CPRs) in which there is an incentive to overexploit the resource and underinvest in sustaining the CPR itself (Ostrom *et al.*, 1999). Overcoming social dilemmas involves defining the access conditions and creating the proper incentives for users to invest in the resource. Traditionally, either market or state-based solutions were envisioned to solve both problems. However, field research and laboratory experiments suggest that in many settings users do not

respond to the "*homo economicus*" model defined in neoclassical economic theory (Ostrom, 1998; Gintis, 2000), but rather tend to reciprocate cooperative behavior and punish free-riders even at a personal cost. In this sense, governance systems at the local level seem to be mediated by social capital factors, such as trust relations, reciprocity, common rules and networks, in addition to pure pecuniary payoffs (Pretty and Ward, 2001).

In the Latin American and Caribbean context, most countries have reformed or initiated the reform of their water institutions (IANAS, 2012). Countries like Brazil, Chile, Venezuela, Mexico, and Peru have recently enacted new water laws, whereas others, as most Central American countries, with the exception of Nicaragua and Honduras, are currently transitioning to new water institutional frameworks. Decentralization of water management has been a centerpiece of most of these reforms. While there is a wide diversity of institutional arrangements in the region, a common feature has been the transfer of irrigation management to users and the reliance on community based organizations for the provision of drinking water in rural areas.

As in other regions, Latin American countries face similar constraints regarding the implementation of water reforms. Dourojeanni and Jouravlev (2001) point out to (1) the complexity of reconciling economic, social and environmental objectives; (2) the dispersion and poor coordination of institutions; (3) lack of transparency in conflict resolution; (4) the trend to "import" management mechanisms poorly adapted to local conditions and (5) the lack of perception about what is necessary or important for resource governance, as the major barriers to IWRM. Although barriers to implementation have been to a large extent identified in the literature, why these barriers develop and make difficult or even paralyze policy implementation has not been answered yet. At the same time, understanding the factors that influence individual decisions related to water resources management can help users and policy makers to design better institutions for the governance of common pool resources.

This thesis analyzes in depth the case of Nicaragua and, more superficially, presents a case study of Suriname. Nicaragua provides a rich setting for understanding the complexities of implementing a modern water reform at both the national and local level, at which mostly informal institutions prevail for the management of water resources, particularly in agriculture. Suriname provides a good example of a water governance change along with a post-colonial transition.

In 2007 Nicaragua enacted a new Water Law after a discussion period of nearly five years. However, the implementation process has proven to be complex and slow. This research attempts to understand the factors delaying this process by connecting them to the institutional statements included in the Water Law. This approach to institutional analysis identifies the major barriers encountered in the implementation

process, conceptualizes them from a social-ecological perspective and analyzes to what extent they are linked to the type of institutions defined in the Water Law.

The new Nicaraguan Water Law approaches water management from an integrated perspective and adopts the river basin as the management unit. Within this hydro-geographical frame, irrigation districts are created with the purpose of managing both water resources and infrastructure for irrigated agriculture. This is a new institutional arrangement as most farmers irrigate their crops individually or in informal groups. This thesis examines collective action in these informal groups with the double objective of, on the one hand, understanding the role of social capital and, on the other hand, informing the development of irrigation districts in the country. In addition, the analysis of collective action is complemented with an experimental approach that addresses how people behave when faced with the type of social dilemmas encountered in collective irrigation systems.

The Surinamese case is included in this thesis as an example of failure and revitalization of collective action in agriculture. This is a particular case in which a colonization and subsequent decolonization process interacts with the governance system of water resources in the country. The study adopts a social-ecological framework to the analysis of the factors that explain the underperformance of Water Boards in the country and the kind of policies and plans that are being implemented to improve water use and encourage farmers' participation.

1.2   Objectives and research questions

The overarching objective of this thesis is to improve the understanding of water reforms implementation at national and local scales in the context of a developing country. For this purpose, this thesis 1) analyzes the implementation of the new Nicaraguan Water Law at a national scale and 2) studies collective action in irrigation at a local level in Nicaragua and, more superficially, in Suriname.

The chapters presented in this thesis consist of independent academic papers, each intended as a separate contribution to the literature. More specific formulations of the objectives of each paper can be found in the corresponding chapters. The research questions addressed in this research work are:

1. What types of barriers explain the delay in the implementation of the new Nicaraguan Water Law (chapter 4)?
2. To what extent factors explaining the delay in the implementation of the new Nicaraguan Water Law are linked to the institutions defined in the Law (chapter 4)?
3. To what extent social capital factors explain collective action in the management of irrigation systems in Nicaragua (chapter 5)?
4. How do people behave on a common pool resource and public good (PG) irrigation game (chapter 6)?

5. To what extent pro-social preferences and information disclosure over appropriation and public good provision influence decisions on a CPR and PG game (chapter 6)?
6. Why decades-old collective irrigation institutions happened to decay so dramatically in Suriname and are proving so hard to rebuild (chapter 7)?

1.3 Outline

The chapters of this thesis are organized as follows. In chapter 2, I describe the context and timeline of this research. In chapter 3, I discuss the relevant literature related to the objective of this thesis and show where the individual chapters contribute to the literature on these topics.

Chapters 4 to 6 constitute the core of this dissertation. Many of the problems regarding water institutional reforms have a political, microeconomic and behavioral foundation. Therefore, institutional and experimental tools used in the policy sciences and economic literature might be suitable for their analysis. Thus, this thesis makes use of both along the subsequent chapters. Table 1.1 presents the relation between the chapters, the type of problem address and the scale of analysis.

Table 1.1 Relation between chapters, the issues addressed and the approach.

		Approach	
		Macro	Micro
Issue	Water reform	Chapter 4	
	Collective action	Chapter 7	Chapters 5 & 6

In chapter 4, I focus on the factors that explain the delay on the implementation of the new Nicaraguan Water Law. In the chapter, I develop an integrated approach to the analysis of implementation reforms, by combining the social-ecological systems framework (SES) and the Institutional Grammar Tool developed by Crawford and Ostrom (1995). This approach is applied to the analysis of barriers relating to the implementation of the new Nicaraguan Water Law. Empirical underpinning is provided by 40 interviews conducted with actors involved in the Nicaraguan Water Law process and the coding of institutional statements included in the Water Law.

In chapters 5 and 6, I switch to the micro level and use households' surveys and field experiments to analyze collective action in irrigation. In chapter 5, the focus is on the determinants of participating in collective, and informal, irrigation institutions in Nicaragua. In particular, the study examines the relation between social capital factors on the participation of irrigation groups. In chapter 6 I make use of experimental economic methods to investigate agents' behavior on irrigation dilemmas. Decisions along the game are connected to behavioral responses on pro-social and risk preferences collected through individual interviews.

Chapter 7 focuses on the case of collective irrigation institutions in Suriname, the factors explaining the decay of Water Boards and the measures adopted to revitalize them. This analysis is based on a set of interviews conducted among representative stakeholders taking part in the irrigation system (i.e. mainly users, managers, government officials and research institutions). Finally, chapter 8 provides a discussion of the main findings of this thesis and suggests some lines for further research.

2   Research context, setting and timeline

In this chapter, I provide an overview of the research context of the thesis. Subsequent chapters provide further insight on the social-ecological system of water resources in Nicaragua and Suriname. Section 2.1 describes the context in which the research activities carried out for the thesis is framed. Section 2.2summarizes basic socioeconomic and environmental data for Nicaragua, Jinotega's Department, where most of the fieldwork was carried out, and for Suriname. In section 2.3 a briefly timeline of the research is presented.

2.1   Research context

2.1.1   TERRENA Program

Most of this thesis is framed within the TERRENA Program(2009-2013). This is a 4-year development aid program supported by the Spanish Cooperation and Development Agency (AECID) and implemented in Nicaragua by the Spanish NGO ONGAWA and the Nicaraguan NGO La Cuculmeca. The main objective of TERRENA is to contribute to vulnerability reduction in impoverished rural areas through access to safe water, sanitation and sustainable management of land and water resources based on an integrated basin approach. In Nicaragua, the program has been implemented in the Upper Sub-basin of Rio Viejo, more specifically in three municipalities of Jinotega's Department: La Concordia, San Sebastián de Yalí and San Rafael del Norte (see Figure 2.1 in section 2.2.2).

TERRENA program is made up of four intervention lines: 1) integrated water resources management; 2) natural risks prevention and mitigation; 3) institutional capacity building and 4) promotion and diffusion of sustainable technologies and management strategies. Line 1 includes water and sanitation provision services, sustainable farm management plans and promotion of mechanisms for conservation and environmental protection. Line 2 consists of updating risk mitigation and prevention plans at municipal and community level, implementing good environmental practices and developing risk mitigation infrastructures. Line 3 covers the strengthening of coordination spaces among municipal governments and the civil society with the objective of improving institutional capacity for territorial management. Lastly, line 4 focuses on compiling and disseminating appropriate technologies and sustainable natural resource management experiences in rural settings.

This thesis is part of TERRENA's line 4 activities. In this respect, the agreement between the Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM) of the Universidad Politécnica de Madrid, and

ONGAWA has provided the institutional framework for the university to collaborate on the development project. The purpose of this collaboration has been twofold. On the one hand, to support the design and development of a pilot irrigation district in the Upper Río Viejo Sub-basin, in Jinotega's Department (Nicaragua). Some of the activities we have carried out consisted on identifying potential farmers willing to participate in this experience, analyze the environmental, economic, social and institutional trade-offs of participating in irrigation districts, developing a blueprint for carrying out this experience and recording its evolution. On the other hand, the TERRENA program provided us with field data and logistic support to carry out the research presented in this thesis.

2.1.2 Inter-American Development Bank (IDB) mission

Chapter 7 of this thesis benefits from the irrigation policy analysis carried out by CEIGRAM for the IDB in Suriname between February 2013 and August 2013 (*Support of modernisation of public agricultural services in Suriname- Irrigation and drainage policy aspects*, UPM OTT P130220c237). IDB's country strategy (2011-2015) for Suriname identifies agriculture as a priority sector for poverty reduction and, in this line, attempts to support sector policy reforms aimed at increasing long term agricultural growth. Agriculture in the country is mainly concentrated in the irrigated production of rice, banana and horticulture in the coastal plains. However, since the 80s the agricultural sector has experienced a decline in production and productivity. Agricultural growth showed a slow recovery at the beginning of the last decade, but in 2010 the national agricultural output was still below the level reached in 1991. Similar facts are observed in the irrigation sector, as large parts of the irrigation infrastructure are presently in a bad condition and require rehabilitation. Water Boards (WBs) were developed during the Dutch colonial period, and date back to the 1930s, but after the country independence in 1975 WBs were progressively disintegrated. More recently, under government's Agricultural Sector Plan 2005-2010, the management and maintenance of irrigation systems has received considerable attention. However, despite these government efforts, none of the water boards is currently under active operation.

The objective of the IDB mission in February 2013, in which the author participated, was to carry out a diagnosis of the irrigation and drainage sector in Suriname and provide a preliminary set of sequential institutional reforms intended to increase the productivity of the agricultural sector, while improving water management and guaranteeing the sustainability of these WBs.

2.2   Research setting

2.2.1 Nicaragua

Nicaragua is a Central American country with 5.87 million people (in 2011 according to World Bank, 2013) and 120,340 km² of land area. In terms of the Human

Development Index (HDI), the 2013 Human Development Report ranks Nicaragua in the position 129 out of 187 countries and territories (UNDP, 2013). Nicaragua's HDI of 0.599 in 2012 is below the average of 0.741 for countries of Latin America and the Caribbean and below the 0.640 average for countries in the medium human development group. When adjusted by inequality, the HDI falls to 0.434 due to the 27.5% loss caused by inequality in life expectancy at birth, education and income.

Table 2.1 reports a number of economic indicators for Central American countries and the Latin American and Caribbean aggregate. Average annual Gross Domestic Product (GDP) growth in Nicaragua for the period 2003-2011 is equal to 3.4% (std. dev. 2.1) and it is lower than the Latin America and Caribbean average of 4.2% for the same period. Nicaraguan GDP amounted to 7170 millions 2000 US$ in 2011, being the lowest of the Central America region.

Table 2.1 Economic indicators for Central American countries, average 2003-2011 (std. dev.).

Country	GDP growth (annual %)	GDP per cap, PPP (const.2005 int.$)	Exports (% GDP)	Food exports (% exp.)	Food imports (% imp.)
Nicaragua	3.4 (2.1)	3138.2 (173.9)	29.5 (6.6)	82.1 (12.2)	14.9 (2.0)
Belize	3.5 (2.7)	6151.3 (152.0)	53.5 (14.9)	74.1 (12.8)	13.7 (1.9)
Costa Rica	4.9 (2.9)	9763.7 (832.0)	44.7 (4.5)	31.0 (3.12)	7.8 (1.0)
El Salvador	1.8 (2.1)	5862.7 (250.7)	26.2 (1.5)	18.2 (3.2)	14.9 (1.9)
Guatemala	3.5 (1.7)	4211.4 (144.4)	25.5 (1.0)	42.0 (5.1)	12.2 (1.2)
Honduras	4.2 (2.7)	3407.7 (210.1)	51.6 (6.4)	60.2 (5.5)	15.4 (1.8)
Panama	8.1 (2.8)	10742.1 (1899.2)	76.6 (6.9)	74.7 (26.3)	9.0 (2.8)
LAC	4.2 (2.5)	9440.6 (769.8)	24.6 (1.2)	16.2 (1.0)	7.5 (0.6)

Source: Own elaboration based on World Bank (2013).

In per capita terms, and adjusted for Purchasing Power Parity (PPP), average GDP in Nicaragua during the period 2003-2011 is the lowest of the Central America region, followed by Honduras and Guatemala with 3407.7 and 4211.4 $ per capita valued at constant 2005 international $, respectively. Nicaraguan Gini index for year 2005 was 40.47 (on a 100 scale[1]) and is the lowest of Central American countries (excluding Belize and Guatemala, for which there are no data) (World Bank, 2013).

Average exports of goods and services represent nearly 30% of Nicaraguan GDP in the period 2003-2011. As shown in Table 2.1, on average, Nicaraguan food

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[1]The Gini index provides a measure of wealth distribution. On a 100 scale, a Gini index of 100 expresses maximal inequality.

exports[2]account for 82% of all merchandise exports (World Bank, 2013). Agriculture value added represents, on average for 2003-2011, 18% of Nicaraguan GDP. This value is higher than the average of 6% for all Latin American and Caribbean countries and highlights the relevant role of the agri-food sector in the country's economy.

Table 2.2 reports agricultural land and water use data. Nicaragua is the Central America country with the larger land area devoted to agriculture (51,460 km² in 2009). Agricultural land accounted for nearly 43% of land area in 2009 and annual freshwater withdrawals amounted to 1.29 billion m³ in 2011. Agriculture is the largest water user sector as annual freshwater withdrawals represent 84% of total water withdrawals. This value is higher than the Latin American and Caribbean average (68%). Nicaraguan 2012 Agricultural Census (INIDE, 2012) shows that total agricultural irrigated land covers 99,387.4 ha, accounting for nearly 4% of cultivated area. However, the area equipped for irrigation, according to the Food and Agriculture Organization statistics (FAO, 2013), adds up to 61,000 ha, representing 12% of total agricultural land. In addition, 63% of total land under an irrigation system is concentrated in large farms with more than 350 ha. However, area under irrigation is less than 2% of agricultural land when considering landholdings smaller than 35 ha (INIDE, 2012).

Table 2.2 Agricultural land, freshwater withdrawals and area equipped for irrigation in Central America countries.

Country	Agric.land[a] (2009, ha)	Agric.land[a] (2009, % of land area)	Annual[a] freshwater withdrawals, total, 2011 (billion m³)	Annual[a] freshwater withdrawals, agric., 2011 (% of total)	Area[b] equipped for irrigation (2009, ha)
Nicaragua	5,146,000	42.76	1.29	83.85	61,000
Belize	152,000	6.66	0.15	20.00	4,000
Costa Rica	1,800,000	35.25	2.68	53.36	108,000
El Salvador	1,544,000	74.52	1.38	55.23	45,000
Guatemala	4,395,000	41.01	2.93	54.89	200,000
Honduras	3,190,000	28.51	1.94	57.79	80,000
Panama	2,2300,000	30	0.45	50.92	43,000
LAC	721,135,000	35.8	270.81	67.78	--

Source: Own elaboration based on [a]World Bank (2013) and [b]FAO (2013).

Demography indicators show that average population density amounts to 48.77 people per km² of land area. Distribution by ages shows that 34% of the total population is below 14 years, 61% between 14 and 64 years and 5% 65 or above. Distribution of people under 14 and over 65 years in Nicaragua is slightly higher than the Latin American average of 27% of population under 14 and lower than the 7% of population over 65. This difference is even larger when compared to the high

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[2] Food exports comprises the commodities in Standard International Trade Classification (SITC) sections 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal and vegetable oils and fats) and SITC division 22 (oil seeds, oil nuts, and oil kernels).

income countries average of 17% under 14 years and 15% over 65 years old (World Bank, 2013).

Table 2.3 presents average data for water and sanitation access and life expectancy at birth. Results for Nicaragua show that the proportion of people with access to both improved sanitation and improved water source is lower in rural than urban areas. Overall, the level of sanitation coverage is lower than water coverage, particularly in Nicaragua where 35.8% and 66.4% of rural population has access to improved sanitation facilities and improved water source, respectively. In the Nicaraguan case, the proportion of total population with access to improved sanitation facilities increased from 50 to 52% between years 2003 and 2010. In this same period, the proportion with access to improved water source rose by 3%, from 82% in 2003 (World Bank, 2013).

Compared to other Central American countries, Nicaragua is the largest Official Development Aid (ODA) recipient. Average net bilateral aid flows from the OECD Development Assistance Committee (DAC) amounted to 580 million US$ (valued at constant 2000 US$) in the period 2003-2010, which stands for nearly 10% of net bilateral aid flows from the DAC to Latin America and Caribbean countries. In addition, on average terms, the net ODA received represents 86% of central government expenses and 13% of Gross National Income (GNI) in the period 2003-2010. These figures suggest the relevance of development and official flows for Nicaragua's economy as compared to other Central American countries. For instance, in Honduras, the second largest development assistance and official aid recipient, the net ODA received accounts for 24% of central government expenses and for 5% of GNI.

Table 2.3 Rural population, water and sanitation access and life expectancy at birth, 2010.

Country	Rural population (% total population)	Improved sanitation facilities (%population with access)	Improved sanitation facilities, rural (% rural population with access)	Improved water source (%population with access)	Improved water source, rural (%rural population with access)	Life expectancy at birth, total (years)
Nicaragua	43.0	52	37	85	68	73.7
Belize	55.0	90	87	98	99	75.8
Costa Rica	35.8	95	96	97	91	79.2
El Salvador	35.7	87	83	88	76	71.7
Guatemala	50.7	78	70	92	87	70.8
Honduras	48.4	77	69	87	79	72.8
Panama	25.4	69*	51*	93*	83*	76
LAC	21.2	78.8	59.7	94.2	81.1	74.1

Note: *Data for year 2009. Source: Own elaboration based on World Bank (2013).

2.2.2 Jinotega

Nicaragua is composed by 15 Departments, two Autonomous Regions (North Atlantic and South Atlantic) and 153 Municipalities. Figure 2.1 shows Nicaragua's political and administrative division. Jinotega's Department is located in the Central-North Region. It covers an extension of 9,222.4 km² and includes eight municipalities and 331,335 inhabitants according to 2005 Census (INIDE, 2005). Central-North Region is located along the Central America drought corridor. Thus, whereas in the Atlantic coast annual rainfall averages 2500 mm, in this region rainfall levels are usually under 1200 mm annually with marked seasonal and intra-regional variability (INETER, 2010).

Figure 2.1 Political Division Map of Nicaragua.Source: INETER (2013a).

According to the Community Level Human Development Report (UNDP, 2002), Jinotega ranks 16th out of 17 departments in Nicaragua in terms of the HDI. The Municipal Poverty Map shows that five out of eight municipalities in Jinotega are in a situation of severe poverty, two are included in the high poverty group and one in the medium poverty group (INIDE, 2005). Poverty Map measures poverty based on the Unmet Basic Needs method (UBN) introduced by the Economic Commission for Latin America on the 80s. INIDE (2005) considers five structural indicators to measure UBS: i) minimum housing standard in terms of overcrowding and construction materials; ii) access to basic sanitary facilities, including water and sanitation; iii) access to basic education and iv) economic capacity in terms of access to employment. A household is considered as extremely poor when there are two or more unmet basic needs. In this respect, a municipality is in a situation of severe

poverty if it is above the third quartile of households in extreme poverty. In Jinotega's Department 59.3% of all households are classified as extremely poor.

Table 2.4 shows that the proportion of households with access to water and sanitation facilities was lower in Jinotega's Department in 2005 than at national level. Regarding sanitation facilities, 52.1% of rural households have a latrine and 47.1% have none sanitation system, what suggests the large incidence of open-air defecation.

Table 2.4 Access to water and sanitation facilities (% households, 2005).

	Water facilities (% of households)		Sanitation facilities (% of households)		
	Pipe inside house	River or wellspring	Toilet &sewage system	Latrine	No system
National	40.5	12	19.4	57.9	15.2
Jinotega	20.3	35.7	1.8	49	38.3
Urban	--	--	43.8	39.5	11.1
Rural	--	--	0	52.1	47.1

Source: Own elaboration based on INIDE (2005).

The economically active population of Jinotega accounts for 49.8 % of total population, out of which 90.2% are employed. 52.8% of the economically inactive population works in the domestic sector (i.e. housewife according to INIDE (2005) definition). While 83.2% of economically active males are employed in the primary sector, most economically active females (69.6%) are employed in the tertiary sector. Overall, 72.7% of the economically active population employed in this sector (INIDE, 2005).

As shown in Table 2.5 major annual crops cultivated in Jinotega are maize and kidney beans ("frijol"). In both cases the Jinotega's maize and beans areas represent 17% of the national area dedicated to these two crops. In addition, Jinotega is the largest coffee producer department in Nicaragua. Coffee accounts for nearly 83% of permanent and semi-permanent crops area.

Table 2.5 Land distribution: forest and crops, ha (2010-2011).

	Forest (ha)	Annual crops (ha)	Permanent crops (ha)	Maize (ha)	Bean (frijol) (ha)	Coffee (ha)
National	797,805	7,319,990	291,879	308,701	224,678	126,154
Jinotega	125,563	81,597	52,579	53,799	38,985	43,617

Source: Own elaboration based on INIDE (2012).

Nicaragua holds the largest rainforest area in Central America. However, since 1950 it has lost approximately half of it (Zeledon and Kelly, 2009). The agricultural frontier has been moving eastward, resulting in large-scale deforestation and affecting the Bosawás Biosphere Reserve. This is the largest rainforest area north of the Amazon in the Western Hemisphere. Bosawás Biosphere Reserve extends through Jinotega's Department and the North Atlantic Autonomous Region.

Deforestation and eastward movement of the agricultural frontier has been significantly shaped by the aftermath of the Sandinista/Contra war in the 90s, when ex-combatants were offered rainforest land in exchange for disarmament (ibid.).

Finally, it is worth noting that the region is highly vulnerable to the effects of global warming. Overall, the Long-term Climate Risk Index ranks Nicaragua as the third country most affected by extreme whether events during the period 1992-2011, after Honduras and Myanmar (Harmeling and Eckstein, 2012). Deforestation might accentuate the effects of global warming, with expected effects on crop yields and food security (Ramirez *et al.*, 2010). Jinotega has the largest arable area in the country and it constitutes the upstream part of the San Juan River Basin, which includes both Xolotlán and Cocibolca Lakes. Therefore, land use changes in the upper part are likely to have important hydrological effects downstream.

2.2.3 Suriname

Suriname is located on the north-coast of South America, bordering on the Atlantic Ocean, with French Guiana to the east, Guyana to the west and Brazil to the south (see Figure 2.2). Surface area is 163,270 km² and with a population of 529,419 inhabitants in 2011 is one of the least densely populated countries in the world. Suriname became independent from The Netherlands in 1975 and it is currently divided into ten administrative districts (see Figure 2.3). Different ethnic groups inhabit Suriname, including Hindustani, Javanese, Creole, Chinese, Lebanese, European, Maroons and indigenous population (Haalboom, 2012). Most population is constituted of descendants of transplanted groups brought to Suriname for plantation agriculture. Creole population (Blacks and mixed-Blacks) living on the coast is distinguished from Maroons, who are descendants of escaped slaves living on the interior zones of the country (Singh, 2008).
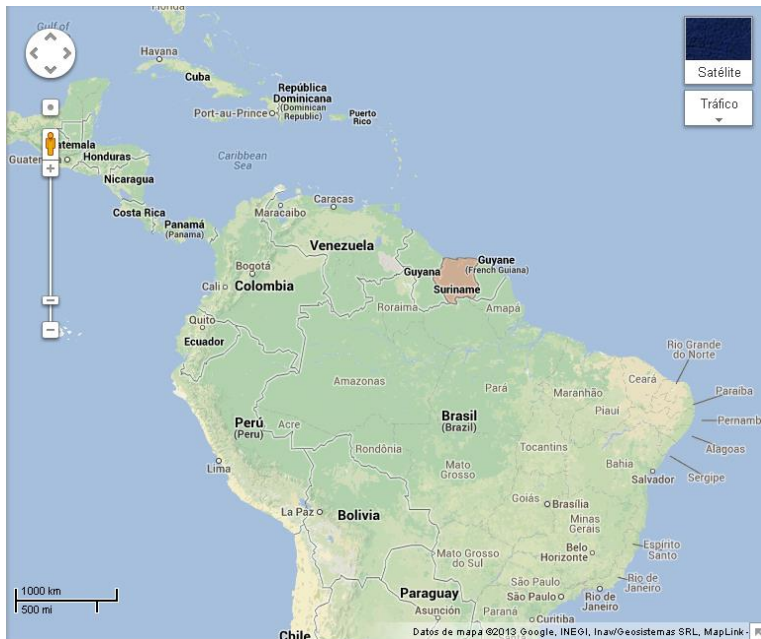
Figure 2.2 Geographical location of Suriname.Source: GoogleMaps (2013).

Figure 2.3 Political division of Suriname.Source: Wikimedia (2013).

The World Bank classifies Suriname as an upper-middle income country (World Bank, 2013). Suriname's HDI value for 2012 is 0.684, in the medium human development category, positioning the country at 105 out of 187 countries (UNDP, 2013). Suriname's HDI is above the average value for the medium human development category, but below the Latin America and the Caribbean average. Within the region, Suriname is close to Guyana and Belize in terms of HDI and population size.

GDP growth in 2011 and 2010 was 4% and 5%, respectively. GDP amounted to 1504 millions 2000 US$ in 2011. Adjusted for PPP, GDP in 2011 is valued at 3906 millions constant 2005 US$, which is equal to 7378 US$ per capita (World Bank, 2013). Trade in services represents, on average for the period 2005-2011, 20% of GDP. The mining sector, mainly gold and bauxite, provides 85% of the country's exports and 25% of government revenues (Briegel, 2012). The economy is highly dependent on mineral exports, in particular, from bauxite (Haalboom, 2012). As argued in de Koning (2011), large multinational companies dedicated to resource production and extraction play major roles in the economy. Food exports account for 2% of merchandise exports in the period 2003-2011, while food imports represent 12% of merchandise imports in the same period.

Agricultural land in Suriname covered 820 km² in 2011, representing 0.5% of total land area. Suriname has one of the highest percentages of tropical rainforest cover in the world. Forest area covers nearly 95% of total land area. As in many other countries, agriculture is the largest water user sector and annual freshwater withdrawals represent 93% of total water withdrawals (2011 data). Annual precipitation is highest in the interior areas (about 2800 mm) and lowest in the northwest of the country (about 1650 mm) (Nurmohamed *et al.*, 2007).

2.3   Research timeline

This thesis was initiated in April 2009, when the author first received the scholarship from the Universidad Politécnica de Madrid (UPM) and the financial and logistical support of the TERRENA program. During this period I have been member of both the Department of Agricultural Economics and Social Sciences at the Universidad Politécnica de Madrid and a researcher at CEIGRAM, a Joint Research Centre of the UPM.

In June 2009 I made my first trip to Nicaragua. I spent there one and a half months during which I carried out most of the interviews for the first paper and fourth chapter of the thesis. Additional interviews were carried out on a subsequent field trip on November 2009. After returning to Madrid I coded the interviews and began the analysis and paper writing. The version presented in the thesis constitutes the last of a number of drafts that have benefited from multiple literature readings and discussions on institutions and public policy.

Along with fieldwork trips to Nicaragua, I had the opportunity of spending two research periods abroad. The first research visiting period was from February to June 2010 at the International Food Policy Research Institute (IFPRI) in Washington, DC, under Dr. Ruth Meinzen-Dick's supervision. The major objective of visiting IFPRI was to work on the second paper (chapter 5) of this dissertation. During the visiting fellowship the survey instrument to gather information related to agricultural production, irrigation and social capital was designed. The interest on analyzing the relationship between irrigation organization and social capital was

motivated by the fact that the new Water Law introduces irrigation districts as a new form of irrigation organization. In addition, as mentioned earlier, our collaboration with the TERRENA program was meant to develop a pilot irrigation district in the Upper Río Viejo Sub-basin. The survey was implemented between June and July 2010 and in February 2011. We analyzed the preliminary results of the survey on a field trip in August 2010 and in February 2011 we broadened the sample.

The second research period abroad took place between September and December 2011 at the Becker Center on Chicago Price Theory at the University of Chicago under Prof. John List's supervision. The main objective of visiting the University of Chicago was to work on the experimental design that constitutes the basis for the third paper and chapter 6 of this thesis. This paper explores the relation between pro-social variables and decisions on a game that combines a common pool resource and a public good. In addition, during this second research stay I was able to attend graduate courses from the Economics program at the University of Chicago. For this paper, I specially benefited from the course on Behavioral Economics. Pilot experiments were tested during a field trip on February 2012. Final experiments were conducted in July and August 2012 in Nicaragua.

Fieldwork in Suriname, with IDB' project, was carried out during a 10-days visit in February 2013. Outcomes from the interviews done in Suriname served as the basis for chapter 7 of this thesis.

3   Institutions, policy processes and collective action in the commons

In this chapter I provide an overview of the literature on institutions, policy processes and collective action and identify where the subsequent chapters of this thesis aim to contribute to this literature. Section 3.1 introduces the literature on institutions and policy processes and focuses, particularly, on the implementation of water reforms, as this is the focus of chapter 4. Section 3.2 discusses collective action theories and the factors that influence collective action in the commons, to which chapters 5, 6 and 7 contribute.

3.1   Institutions and the policy process

3.1.1   *Institutions*

Social dilemmas occur whenever maximization of short-term individual payoffs leads to a situation that leaves all participants worse-off than a feasible alternative. Most of public policy analysis is based on the assumption that individuals are trapped in social dilemmas from which they cannot escape without external intervention. However, policies based on this assumption very often fail to ameliorate the problems they were intended to solve (Ostrom, 1998). In the case of natural resources, policy decisions based on neoclassical economic theory and the rational choice approach have proven to be inefficient in an ample number of cases (Saleth and Dinar, 2004). The fact that the quality of institutions is key for the long term economic growth has been widely recognized in the literature (Acemoglu *et al.*, 2001; Easterly and Levine, 2003; Rodrik *et al.*, 2004; Collier, 2007, among others). However, as Rodrik (2006) states, institutional reforms are long and complex process for which there are not universal, comprehensive and top-down solutions.

There are multiple definitions of the concept "institutions". Veblen (1919, p. 239), founder of the "old" institutionalism, refers to institutions as "settled habits of thought common to the generality of men". Commons (1968) points out that institutions define the set of actions that individuals and groups can and cannot do in a given context. The working rules of a society indicate what "individuals must or must not do (compulsion or duty), what they may do without interference from other individuals (permission or liberty), what they can do with the aid of collective power (capacity or right), and what they cannot expect the collective power to do on their behalf (incapacity or exposure)" (Commons, 1968, p.6). Thus, from an "old" institutional perspective, the concept of habit is at the core of institutional analysis and the evolution of institutions (Hodgson, 1998). In this respect, evolutionary biology has had a major influence in the areas of institutional and behavioral economics (Alchian, 1950; Nelson and Winter, 1982; Simon, 1979, among others).

In his widely read book, North (1990, p.3) defines institutions as "the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction". In this respect, institutions define and limit the set of available individual and collective choices, determine the structure of incentives and reduce the level of uncertainty that individuals face (North, 1990). Coase (1960) argues that, particularly, when there is incomplete information, institutions may act as substitutes of information in complex and uncertain contexts. Thus, institutions would be the way of interpreting and transforming information into knowledge (Hodgson, 1998).

Crawford and Ostrom (1995) use the concept "institution" to define the set of shared concepts used by individuals in repetitive situations organized by certain rules, norms and strategies. These authors propose the term "institutional statement" to refer to "a shared linguistic constraint or opportunity that prescribes, permits, or advises actions or outcomes for actors (both individual and corporate)" (Crawford and Ostrom, 1995, p.583). In this way, institutions determine the economic incentives, the action situations and the interaction patterns among the actors participating in the action (Bromley, 1989; Ostrom, 1990).

Despite the differences in the definitions, Hodgson (1998) identifies a number of shared characteristics which broadly define the concept of institutions. On the one hand, institutions entail the interaction of agents and feedbacks in information flows. On the other hand, institutions maintain and, at the same time, are maintained by certain shared expectations and knowledge. Although institutions are dynamic, that is, institutions emerge, evolve and, eventually, disappear, they tend to persist and remain over time. In addition, institutions express or reveal what can be understood as morally just.

Based on the frequency of change and objectives, Williamson (2000) defines four levels of social analysis. The top level is the social embeddedness level. That is, the informal institutions, customs, traditions, religion, etc. Institutions at this level change very slowly. The second level is the institutional environment, defined as the formal rules of the game. Property rights and legislation are important components of this level. The third level is referred to as the governance structure. The fourth level is where the resource allocation takes place. The "new" institutional economics (NIE) focuses mainly on the institutional environment and the institutions of governance. Property rights, laws, polity, bureaucracy and power distribution are at the core of the institutional analysis.

The NIE, as opposed to "old" institutional economics, considers the social context as given. Emergence of institutions is explained based on a rational model of individual behavior (Hodgson, 1998). However, proponents of the "old" stream consider that the individual cannot be taken as given, as it is both a producer and product of his/her circumstances (ibid.). In this sense, both knowledge and learning are intrinsically linked to the process of institutional change.

From a sociological point of view, Granovetter (1985, 1992) argues that institutions are embedded in the social structure and, therefore, socially constructed. Thus, institutions do not emerge automatically or are only driven by exogenous factors. Thereby, factors as trust, cultural systems and social obligations play an important role in the analysis of institutions and governance.

Saleth and Dinar (2004) highlight five key features of institutions. First, their subjective nature, as institutions are often characterized as "belief systems" or "mental constructs". Second, their path dependency, implying that history matters for institutional change. As informal institutions tend to change more slowly than formal institutions, informal and formal institutions are also connected through temporal linkages (North, 1990). Third, their relative stability, self-reinforcing nature and persistence (Hodgson, 1998). As a result, institutional changes are often gradual and incremental (North, 1990). Fourth, there is the hierarchic and nested nature of rules. Kiser and Ostrom (1982) distinguish three levels of nested rules affecting action situations: constitutional, collective and operational rules. Constitutional-choice rules establish the processes through which collective-choice rules are defined. Collective-choice rules determine how institutions are constructed and policy decisions made. Operational-choice rules refer to the implementation of practical decisions by those actors allowed to participate, as defined by the collective-choice rules (McGinnis, 2011). Fifth, the embeddedness and complementarities of institutions as formal rules cannot be separated from the informal rules and the performance of the former is influenced by the latter.

North (1990) stresses the difference between institutions and organizations. Institutions define the set of opportunities available in a society, while organizations are in charge of taking advantage of these opportunities. In this way, as organizations evolve, so do institutions. The symbiotic relationship between institutions and organizations defines the process of institutional change. From a political economy perspective, the linkages between power and property rights, as well as the balance among different stakeholders, determines to a large extent the direction of the institutional change (Bromley, 1989; Saleth and Dinar, 2004). In this respect, the policy process determines "who gets what, when, and how" (Lasswell, 1936). Power, in its classical definition, is "the probability that certain specific commands (or all commands) will be obeyed by a given group of persons" (Weber, 1947, p. 324). Power allows subjects to have access to strategic resources and information (Williamson, 1981) and, in this way, to benefit from participating in the economy (Bates, 2005).

3.1.2 *Institutions' emergence and institutional change*

Both "old" and "new" institutional economics concur to point the role of ideology, belief systems and mental models as drivers of institutional change (Saleth and Dinar, 2004). However, both approaches diverge in the definition of the factors that

originate and guide this change. From the perspective of "old" institutional economics, and drawing on the literature on evolutionary biology, processes of imitation and selection allow individuals to adopt certain routines or habits and, in this way, the emergence and consolidation of institutions (Hodgson, 1998). Commons (1934) suggests that habits evolve into routines or customs. Therefore, the evolution of institutions is to some extent conditioned on the curse of history, as previously mentioned.

According to the competitive selection theory, institutions emerge due to the existence of additional benefits that the institutions in place are incapable to capture (Saleth and Dinar, 2004). However, in addition to the economic forces, other authors point to the role of power relations and learning processes as drivers of change (Knight, 1992; North, 1994; Eggertsson, 1996).

From the transaction costs perspective, a reform or institutional change might take place when the opportunity cost of the reform is higher than the transaction costs. In this sense, Demsetz (1967) argues that institutions emerge when the benefits exceed the costs. Thus, rational actors or actors with bounded rationality would be expected to choose the institutional setting that minimizes transaction costs while meeting their preferences (Alchian, 1950). However, institutional changes do not often result in efficiency improvements as issues linked to power distribution might affect equity and efficiency objectives (Bromley, 1989).

Institutional changes might be motivated by both exogenous and endogenous factors. Technological development might be an endogenous driver of institutional change as it might creates a tension between current structure of property rights and the economy's production potential (North, 1981; Eggertsson, 1990). From a supply and demand point of view, Ruttan and Hayami (1984) suggest that institutional changes respond to changes in the structure of incentives. North (1990) identifies changes in relative prices and preferences as the major causes of institutional change. A key aspect introduced by North (ibid.) is the role of ideology, considering this as a mental model shared by a group of individuals. Thus, in order to understand a process of institutional change, it is important to understand how the actors involved in the process interpret and prescribe the direction of change.

In countries largely relying on international aid, the role of international donors and multilateral and bilateral agreements cannot be disregarded. In addition, other exogenous factors, as political or environmental crises, can induce changes in the institutional structure (Saleth and Dinar, 2004).

Regarding water resources, as scarcity, competence and conflicts increase, the need for better institutional frameworks is more patent. As water rights determine to a large extent people's capacity to access and control water resources, many countries have focused on reforming their water rights systems (Bruns et al., 2005a). Schlager and Ostrom (1992) consider water rights as a bundle of rights defined by the right to

access (to enter a property), withdrawal (appropriation of water resources), management (regulation of water resources), exclusion (who will have access and how the right might be transferred), and alienation (right to sell or lease the water right). In addition, Meinzen-Dick and Nkonya (2007) add the right to obtain rents from using the resource. An authorized water user has typically the right to access and withdraw water resources.

Bruns *et al.* (2005b) summarize a number of common features to the water rights reforms reviewed in the book. Thus, in all cases the national and/or local governments are the major promoters or triggers of these reforms. In the case of developing countries, these authors highlight the role of international organizations, as the World Bank and development agencies in encouraging water rights reforms. Overall, water reforms seem to be promoted by agents out of the water sector, but developed according to the perception of elites and water sector policies. In this line, Wilder (2010) points out that water transitions in developing countries are often part of broader policy and political changes, since most of these countries are also in a regime transition toward democratization.

With respect to the role played by civil society groups, Bruns *et al.* (2005b) indicate that in most cases their position did not transition from the opposition to the proposition or implementation of their proposals, particularly in the Andean region. In addition, most water rights' reforms focused on surface water, paying less attention to groundwater resources. Regarding water allocation, in most cases a government agency had initial control of the resources. Nevertheless, most reforms have promoted the transfer of management responsibilities, as well as users' participation in the reform process and resources management.

Saleth and Dinar (2005), in line with Bruns *et al.* (2005b), suggest that exogenous factors, as macroeconomic crises or policy reforms, are the major triggers for water reforms. In case of adverse contexts, because of financial, social or political barriers, these authors recommend implementing selective and sequential reforms, focusing on those sectors high more expectations on the institutional change. Thus, although actors show different preferences, which might follow the specific rule system (Di Gregorio *et al.*, 2008) and/or result from certain economic and political interests, their capability to influence the process of institutional change is closely linked to their action resources. A key power and action resource is information, i.e. how, when and who possess or has access to what information in such a way that the most powerful actors have higher probability of carrying out their own will (Weber, 1947). Linked to information access and the capability for agency are the social, economic and political networks. Meijerink and Huitema (2010) highlight the role of coalition building as a mechanism to influence policy transitions.

3.1.3 The policy process

Institutional changes entail a policy process, that is, "a change and development of policy and the related actors, events, and contexts" (Weible *et al.*, 2012, p.3). A large body of literature on public policy has been devoted to the study of the policy process and how to influence this process (Niles and Lubell, 2012; Nowlin, 2011). Traditionally, policy analysis research has focused on the study of the interactions among stakeholders, bureaucrats and legislators (Parsons, 1995). In this line, the most influential approach until the mid-1980s was the stage heuristics, which divides the policy process into a number of stages: agenda setting, policy formulation and legitimating, implementation, and evaluation. However, Sabatier (2007) argues that this approach has been subjected to strong criticisms because it does not meet the criteria of a scientific theory and lacks empirical and conceptual development.

Other policy process theories and frameworks focus on particular stages of the policy process. Thus, the multiple streams framework (MS) pioneered by Kingdon (1984) identifies three streams in the policy process. A problem stream is defined by a number of indicators and the proponents of problems definitions. The problem stream can be used politically to attract the attention of citizens and policy makers to different problems. A policy stream consists of solutions to the problems defined and is composed of three elements: the national mood, pressure group campaigns, and administrative or legislative turnover (Zahariadis, 2007). Usually, the three streams operate independently, except when a policy window opens and policy entrepreneurs are able to couple the three streams and increase the likelihood of policy adoption. The multiple streams framework addresses questions related to agenda setting, policy attention and policy selection. For this purpose, it considers decision making to be based on the garbage can model, characterized by organizations with problematic preferences, unclear technology and fluid participation (Cohen *et al.*, 1972).

The punctuated equilibrium theory (PET), developed in the US context, argues that policy processes are characterized by long periods of stasis and incremental changes interrupted by short periods of large-scale changes (Jones, 2001). Equilibrium periods are defined when a problem is maintained within the policy subsystem. Disequilibria occur when the problem rises to the macro political agenda. Positive and negative feedbacks characterized instability and stability periods, respectively. According to True *et al.* (2007), the interaction between policy images and institutional designs determines to a large extent whether a problem will receive positive or negative feedbacks.

As reflected in Weible *et al.* (2012), some of the theories and frameworks approach the policy analysis from the perspective of human actions and how institutions and policies emerge from these actions. Thus, the Advocacy Coalition Framework (ACF) analyzes the interactions among the different coalitions formed within the policy subsystems (Sabatier and Jenkins-Smith, 1993). The behavior of policy participants is

affected by two types of exogenous factors. On the one hand, a fairly stable factor linked to the features of the problem, the resource allocation and the socio-cultural and constitutional structure. On the other hand, a quite dynamic factor related to changes in the socioeconomic context, in other subsystem's policy decisions and in the governmental or dominant coalition. In this sense, a necessary but not sufficient condition for policy change is that one of the dynamic factors change (Sabatier and Jenkins-Smith, 1993).

The ACF argues that beliefs systems' changes determine policy transitions. Three levels of belief systems are defined. The first level referred to as deep core beliefs implies normative and ontological assumptions about fundamental values and human nature. At the second level are policy core beliefs. As both deep core and policy core beliefs involve fundamental choices, they are very difficult to change. The third level consists of secondary beliefs. This level is related to more specific issues, as certain type of rules, and, therefore, secondary beliefs are easier to modify. In its original version, the ACF identifies two critical paths for beliefs and policy change: policy-oriented learning and external perturbations. Later versions include two new paths for change: internal perturbations and negotiated agreements among coalitions (Sabatier and Weible, 2007).

The social construction and policy design framework (Ingram *et al.*, 2007) argues that policy makers usually define targeted populations based on the distribution of benefits and costs of a certain policy. In this way, policies reflect and perpetuate social constructions.

Part of the policy literature focuses more on explaining emergence, adoption and rejection of policies over time. For example, the network approach defines a typology of networks based on power distribution (concentrated vs. fragmented) and type of interaction (conflict, bargaining and cooperation). Policy networks influence the intensity and direction of the policy change. Thus, conflict situations tend to provoke rapid policy changes, whereas cooperative or bargaining structures favor the *status-quo* (Adam and Kriesi, 2007). The diffusion and innovation framework (Walker, 1969; Berry and Berry 1990, 2007) focuses on how similar policies are adopted in different contexts (Nowlin, 2011).

The Institutional Analysis and Development (IAD) framework (Ostrom 1990, 2005a) emphasizes the role of policy actors within a single "action situation". The term "action situation" refers to the relevant participants, as well as the resources and options they face, to affect a certain process. The IAD considers multiple levels of analysis given the nested nature of rules. Three levels of rules are distinguished. Thus, operational rules refer to day-to-day activities, such as provision, appropriation or production activities. Collective-choice rules define policy decisions that affect both participants and rules at the operational level. Constitutional rules determine who is eligible to participate in policy making and the rules to undertake policy

making at the collective-choice level. The IAD framework focuses on institutional arrangements in collective action situations and has been mainly applied to the analysis of common pool resources (Nowlin, 2011).

The IAD has inspired the more recent Social-Ecological Systems (SES) framework (McGinnis, 2011). The SES framework integrates social, political and ecological process into the policy analysis (Ostrom, 2009). Being the IAD framework the major policy framework based on institutions, the SES expands this approach by considering the broader social, political and ecological setting in which institutions are embedded (Nowlin, 2011). Based on the definition of institutions as "shared concepts used by humans in repetitive situations organized by rules, norms, and strategies" (Ostrom, 2007a), Crawford and Ostrom (1995) developed the grammar of institutions. The institutional grammar has been recently applied to the analysis of institutions in legal and policy documents (Basurto *et al.*, 2010; Siddiki *et al.*, 2011, 2012).

Chapter 4 of this thesis contributes to the literature on implementation research by applying an integrative approach that combines the SES framework, in a broader and contextual application, and the institutional grammar tool, as a micro-level institutional analysis. Implementation research is an area of public policy that has been growing and expanding since the 1970s (Saetren, 2005). However, a vast majority of implementation studies have a North American empirical focus, being Latin America and Oceania the most neglected regions within this literature (ibid.). This thesis contributes to fill this regional gap and contextualizing the research in a developing economy, in which water reforms take place along with deeper institutional changes.

3.2   Collective action in the commons

Since Hardin's *Science* article in 1968, a large body of literature has been devoted to the study of the commons and the factors that facilitate or impede collective action in managing common pool resources. The traditional theory of the commons reflected in Hardin's logic predicts the overexploitation of shared resources and presents privatization or state management as the only way of avoiding the "tragedy of the commons" (Poteete *et al.*, 2011). In the absence of an external regulator, overexploitation of shared resources would be the most likely outcome as total resource appropriation would surpass the optimal economic level of appropriation. This prediction is in line with the Prisoner's Dilemma (PD) game in which the dominant strategy is to defect, reaching a final outcome in which both players are worse off than in a cooperative solution as a result of maximizing individual rather than social payoffs.

From an individual rational point of view, Olson (1965) challenges the group theory idea that individuals within a group tend to pursue the common interest. However, what Mancur Olson suggests in *The Logic of Collective Action* is that individuals do not

necessarily act in support of their group interests, unless there is coercion or the benefits for the group are higher than individual benefits and both individual and total costs.

The logic underlying the commons problem or the unlikelihood of cooperation in the commons rests on the fact that common pool resources are characterized by rivalry and low, or costly, exclusion. Rivalry in consumption or subtractability of use implies that the consumption enjoyed by an individual cannot be enjoyed by someone else and, therefore, may result in resource allocation problems, such as congestion or overexploitation. Lower exclusion means that it is very difficult or too costly to exclude other people from consuming the good, creating the incentives for individuals to free-ride on the efforts of others to provide the good.

The pioneering work of Ostrom and her colleagues at the Workshop of Political Theory and Policy Analysis[3] challenged conventional policy prescriptions to overcome the commons dilemma and showed alternative institutional arrangements for managing CPR, as in self-organized and self-governed CPRs (Ostrom, 1990).

Based on an analysis of different case studies, Ostrom (1990) identifies eight design principles that characterize robust institutions for managing CPRs. Thus, institutional design principles include 1) well-defined boundaries; 2) congruence between appropriation and provision rules and local conditions; 3) collective-choice arrangements; 4) monitoring; 5) graduated sanctions; 6) conflict-resolution mechanisms; 7) minimum recognitions of rights, and 8) nested enterprises. A recent review of these principles carried out by Cox *et al.* (2010) reformulates principles 1, 2 and 4 and divides each of them into two components. Regarding principle 1, these authors propose to consider user boundaries and resource boundaries separately. With respect to principle 2, a distinction is made between the congruence with local social and environmental conditions and the congruence between appropriation and provision decisions. Finally, regarding principle 4, two monitoring aspects are considered: on the one hand, the presence of social monitoring and, on the other hand, the presence of environmental monitoring.

Management of CPRs takes usually place in uncertain and complex contexts and, therefore, is very often subject to trial-and-error procedures. Information on the resource system reduces uncertainty levels (Chermak and Krause, 2002; Fischer *et al.*, 2004). However, in the presence of opportunistic behavior, uncertainty remains even if individuals have acquired significant information on the resource dynamics (Ostrom, 1990). Uncertainty affects appropriation and provision decisions over time. The more uncertain individuals are about the resource system or peers' behavior, the more they will discount the future, increasing resource appropriation in the present (Budescu *et al.*, 1995).

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[3]Currently known as "The Vincent and Elinor Ostrom Workshop of Political Theory and Policy Analysis".Indiana University (http://www.indiana.edu/~workshop/).

Development of stable and long-term commitments requires the existence of shared norms about the type of actions that individuals may undertake and the level of rule enforcement. In a context in which rules can be broken without impunity or few individuals share norms about the type of actions that are allowed or constrained, each individual must expect all others to act opportunistically regarding CPR appropriation and provision strategies (Ostrom, 1990). However, a number of studies suggest that individual cooperation might increase if participants have the opportunity to sanction others in the group (Lindbeck, 1997; Gächter and Fehr, 1999; Rege and Telle, 2004; Travers *et al.*, 2011). In addition, as collective action problems related to CPRs extend over time, participants can make use of contingent strategies, such as tit-for-tat, to overcome social dilemmas (Axelrod, 1984). Communication has also been pointed out as a relevant factor contributing to cooperation as it might reduce free-riding (Baland and Platteau, 1996; Ostrom, 1990).

Collective action related to the appropriation and provision of CPRs faces problems of credible commitment and mutual monitoring (Ostrom, 1990; Coleman, 2009). Establishing credible commitments is intrinsically linked to solving mutual monitoring problems, which depend on factors as the cost of monitoring, the benefits of opportunistic behavior, the punishment imposed for breaking the rules and the reward a monitor receives for detecting rule-breakers (Ostrom, 1990). Poteete *et al.* (2010) highlight the central role of trust for solving typical collective action problems.

Human and social capital creation is related to organizations' performance (Meinzen-Dick *et al.*, 2002). Social capital is often considered an intangible action asset that facilitates collective action and self-organization (Putnam, 1995; Meinzen-Dick *et al.*, 2004; Bodin and Crona, 2008). According to Coleman (1988), social capital is inherently linked to the relations among actors. By reducing the cost of cooperation, social capital also diminishes the likelihood of strategic behavior (Putnam, 1995; Pretty and Ward, 2001). However, the specific reasons explaining why social capital facilitates collective action are still under scrutiny. In this respect, Ishihara and Pascual (2009) make use of the concepts of 'common knowledge', defined as the capacity to represent individuals' preferences as the community preferences, and 'symbolic power', which is related to the question of whose preferences are represented, for explaining how social capital may foster collective action. It is also worth noting that despite social capital being regarded intrinsically positive, Pretty and Ward (2001) highlight the fact that not all forms of social capital imply higher social welfare. For instance, Adhikari and Goldey (2010) argue that rule-breaking with impunity and elites' capturing of resources affect collective action and the sustainability of community based organizations. In this respect, social capital may reinforce and sustain inequality, as well as forms of networks with negative social outcomes.

Norms of behavior influence the way individuals perceived and weight actions within specific situations. Microsituational[4] variables inform individuals about the structure of the action situation, affecting their judgment about the costs and benefits of cooperation and, in turn, the social, economic and environmental outcomes (Poteete *et al.*, 2010; Anderies *et al.*, 2011). According to Poteete *et al.* (2010), Six microsituational variables have been identified as increasing trust and positively affecting outcomes in experimental social dilemmas: 1) high marginal per capita return of cooperation; 2) security that contributions will be returned if not enough others contribute; 3) the reputations of the others are known; 4) longer time horizon; 5) capability to choose to enter or exit the group and 6) communication is feasible among the full set of participants. In addition, three structural variables have been associated both positive and negative impacts in cooperation: 1) size of the group; 2) information about the average contributions is made available and 3) sanctioning capabilities. A structural variable, heterogeneity in benefits and costs, has been usually associated with poor levels of cooperation. Heterogeneity in positions and access is typical in CPRs settings. Such asymmetry in access might reflect power relations and be the result of geography, social organization, skills, or technology (Janssen *et al.*, 2012).

Chapters 5-7 of this thesis contribute to further the understanding of the role of microsituational variables in enabling cooperation. Chapter 5 focuses on the relation between social capital and collective action and determines to what extent higher levels of social capital and community participation relate to collective irrigation in a context of informal institutions. Chapter 6 contributes to the literature on experimental economics by combining both an appropriation and provision dilemma in a dynamic context. In addition, the heterogeneity introduced in the game, in terms of access to the resource and group composition by sex, along with an information treatment provide new insights about how these variables affect collective action. Chapter7 adopts a SES approach to analyze the factors explaining the failure of collective irrigation systems in Suriname. In this respect, the major contribution of this study relies in combining the SES approach and the theory of collective action to the analysis of self-organization in a post-colonial context, highlighting the challenges of water reforms and collective organizations in these settings.

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[4]Microsituational variables refer to context specific factors affecting individuals' choices (Poteete *et al.*, 2010).

4   From policy design to implementation: An institutional analysis of the new Nicaraguan Water Law

Abstract

The objective of this chapter is to identify the type of barriers related to the implementation of a new Water Law in Nicaragua. By exploring the perceptions of 40 actors involved in the Nicaraguan Water Law process this article finds that major barriers are related to the power configuration of the water administration system, which creates conflicts of competences within government and at local and national levels. Our research suggests that decision-making is highly centralized, whereas local governments remain unpowered despite their relevant role in water management. One of the particularly novel aspects of this paper is the linking of interview data to grammar coded institutional statements along the social-ecological systems variables. The institutional grammar tool is used to identify the institutional statements of the Nicaraguan Water Law and to connect the interview results to the institutional configuration of the Water Law. This allows us to understand to what extent the Water Law modifies both the formal and informal institutions that are in place.

Publications

- Novo, Paula, and Alberto Garrido. (*under review*). From policy design to implementation: An institutional analysis of the new Nicaraguan Water Law.
- Novo, Paula, and Alberto Garrido. 2011. The new Nicaraguan Water Law in context: Institutions and challenges for water management and governance. *13th Biennial Conference of the International Association for the Study of the Commons*. 10-14 January 2011, Hyderabad, India.
- Novo, Paula, and Alberto Garrido. 2010.*The new Nicaraguan Water Law in context: Institutions and challenges for water management and governance*. IFPRI Discussion Paper 01005. International Food Policy Research Institute, Washington, DC.

4.1   Introduction

Over the last decades, most developing countries have made a significant effort to reform their water institutions. The Dublin Principles, as stated at the Dublin Conference in 1992, and their emphasis on integrated water resources management and on the principles of sustainability, equity and water resources conservation, have guided most of these reforms. However, as shown in recent reviews of reforms of water institutions, the outcomes of implementation have differed across countries owing to a variety of structural, scale-related and political economy factors (Araral, 2010a, Rogers, 2002; Saleth and Dinar, 2005; Bruns *et al.*, 2005b; Shah, 2007).

As institutions define the set of constraints or opportunities to individual choices, they determine the type of actions that are advised, permitted and forbidden (Ostrom, 2007a). Changes in institutions usually imply a reallocation of rights and responsibilities and, as a direct consequence, a reshuffling of economic power and political influence (Agrawal and Ribot, 1999). Because of this, implementation is often considered one of the most critical aspects of the policy process (Grindle and Thomas, 1991).

The objective of this article is to identify the type of barriers related to the implementation of a new Water Law in Nicaragua. For this purpose, we conducted 40 in-depth interviews with a sample of representative actors involved in the Water Law process. Our work has two analytical underpinnings. First, the social-ecological systems (SES) framework proposed by Ostrom (2007b, 2009) is used to frame the study and systematically organize the relevant barriers related to Water Law implementation and identified in the interviews. Secondly, the institutional grammar developed by Crawford and Ostrom (1995) is used to identify the institutional statements of the Nicaraguan Water Law and to connect the interview results to the institutional configuration of the Water Law. One of the particularly novel aspects of this paper is the linking of interview data to grammar coded institutional statements along the SES variables.

Crawford and Ostrom (1995, p.583) define the institutional statement as "the shared linguistic constraint or opportunity that prescribes, permits, or advises actions or outcomes for actors (both individual and corporate)". Based on whether or not the statement includes any prescriptive and sanction element, it identifies three types of institutional statements: strategies, norms and rules. The analysis of institutional statements provides systematic information that can be used for mapping political processes and supports the analyses of actors' perceptions regarding institutional reforms (Siddiki *et al.*, 2011). By focusing on how the characteristics of the reform affect action situations, outcomes from institutional reforms can be analyzed and, ultimately, anticipated.

The new Nicaraguan Water Law represents the first attempt to implement a Water Law in that country. The new Water Law incorporates the approach of integrated

water resources management and sets up a new legal framework for putting the
Dublin Principles into practice. However, the process of implementation has been
slow and, as of 2012, remains far from complete. The National Water Authority
(*Autoridad Nacional del Agua*, ANA), which should have been created in September
2008,was not established until June 2010, and its financial and programmatic
resources allocated to the ANA are still very limited.[5]

This chapter is organized in eight sections. In the next section, we review the
literature on policy implementation. In section 4.3, we present the analytical
approach and section 4 describes the research methodology. Section 4.5 provides an
overview of the new Water Law. Section 4.6 describes the social-ecological water
system in Nicaragua, and section 4.7 summarizes the major results obtained from the
Water Law and interviews' coding and how results from interviews are linked to
institutional statements in the Law. The final section describes the major
implications of this study for Water Law implementation in Nicaragua and for future
studies on water reforms.

4.2   Factors Affecting Implementation

The literature on policy implementation provides a set of explanations for
opposition, delay or failure to reform implementation. In their seminal book,
Pressman and Wildavsky (1973) present an anatomy of implementation delay based
on the actor's relationship to a program along the direction of the preference on the
matter at issue, the intensity of this preference and the available resources to affect
the outcome. Minimal delay is expected when the direction is positive and intensity
is high. On the opposite, maximal delay might be expected in case the direction is
negative and the actor cares a lot about it. Subsequently, the framework developed
by Sabatier and Mazmanian (1980) identified six sufficient and generally necessary
conditions for effective implementation: i) clear and consistent objectives, ii)
adequate causal theory, iii) implementation process legally structured to enhance
compliance, iv) committed and skillful implementing officials, v) support of interest
groups and sovereigns, and vi) changes in socioeconomic conditions which do not
substantially undermine political support or causal theory.

Based on an analysis of 12 reform initiatives, Thomas and Grindle (1990) suggest
that the characteristics of the reform determine whether reactions are found in the
public or in the bureaucratic arena. When (i) the costs are broadly dispersed on the
population, (ii) the direct benefits are not widely spread or valued by the same
population, (iii) administrative and technical content is limited so the reform requires
little infrastructure to be implemented, (iv) extensive public involvement is required
and (v) the impact of policy change is immediately visible, reactions are likely to be
found in the public arena. Bureaucratic opposition is more likely when the costs are

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[5] National Budget allocated to ANA accounted for nearly US$ 272,000 in 2011 and US$ 868,000
in 2012 (MHCP, 2012).

concentrated in the government, dispersed benefits become visible in the longer term, administrative and technical contents are complex, little participation is required and longer time is needed for implementation. In addition, Thomas and Grindle (1990) point to political stability, policy timing in relation to other unpopular policy reforms, government's autonomy with respect to powerful interests and elite support as relevant factors for implementation. Political opposition or support depends intrinsically on the location, organization and socioeconomic status of groups and individuals in the public and bureaucratic arena.

In a review of water institutions reforms, Araral (2010a) argues that political economy aspects, such as the definition and allocation of water rights, are often the most difficult to manage. In this respect, the author points out the need of political leadership in order to manage elite perceptions, mobilize interest groups and marshal coalitions for reform. Hearne and Donoso (2005) and Thanka and Fuller (2010) also highlight the role of the private sector and agrarian interest groups in supporting water reform implementation.

From a transaction cost perspective, Shah (2007) suggests that when transaction costs are high, policy actors are not willing to enforce regulations at any cost. As a result, systems may become trapped in suboptimal social situations from which it is difficult to escape (Thanka and Fuller, 2010). In the case of developing countries, Shah (2007) highlights that the low level of water sector formalization is observed in the low interface between the formal rules and the institutional arrangements that are in place.

As suggested by Wilder (2010) and Thanka and Fuller (2010), water transitions in developing countries are often embedded in broader democratic and economic changes. The national political landscape is therefore more uneven, and international donors are often relevant actors in the policy arena. Jouravlev (2001) suggests that the proliferation of organizations along with the lack of coordination, institutional fragmentation and dispersion of responsibilities and competences are common problems for water reform implementation in Latin American countries. Political factors, such as politicization of technical activities and public order problems, are in many cases important barriers for law implementation. Hendriks (2009) stresses that the legitimacy of long-term reforms largely rests on the inclusivity and accountability of decision procedures. However, so far most attention has been provided to transition goals and not to procedural matters.

4.3 Social-Ecological Systems Framework and the Institutional Grammar Tool: A Systematic Approach for Organizing an Analysis of Implementation Barriers

Overall, the literature on policy implementation has mainly focused on social, political and economic factors. In this study, we apply the SES ontological framework developed by Ostrom (2007b, 2009) to systematically organize the

barriers related to Water Law implementation. The SES framework pays equal
attention to both the social and ecological components of action situations and,
therefore, might provide further insights about the relevance of ecological variables
regarding the limits to Water Law implementation. The analytical framework,
presented in Figure 4.1, considers the impact of the institutional water reform on the
following SES broad variables: the governance system (GS); the users' characteristics
(U); the resource system (RS) and the resource unit characteristics (RU). In addition,
these variables are influenced by the social, economic and political setting (S).
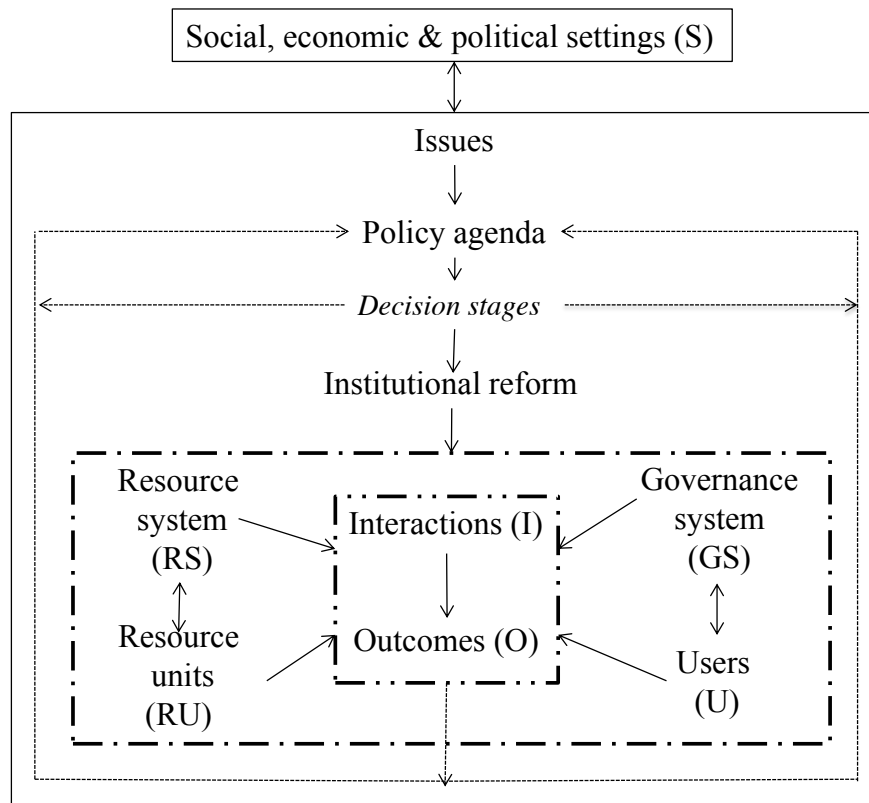
Figure 4.1 Framework for analyzing water law implementation. Source: Own
elaboration based on Thomas and Grindle (1990) and Ostrom (2007b, 2009).

Social-ecological variables represented in Figure 4.1 can be unpacked into second-
tier conceptual variables, as shown in Table 4.1. Second-tier variables enable us to
characterize each of the conceptual variables within the Nicaraguan context and to
analyze the extent to which they are affected by the reform of water institutions. In
this way, this framework allows us to link the conceptual variables to the interviews'
responses and the institutional statements in the new Water Law. Although our
empirical approach focuses on the national and macro level, the framework
considers a multilevel action perspective. This means that action situations could be
assessed at different system levels.

Table 4.1 Conceptual variables for analyzing water law implementation.

Socioeconomic and political setting (S)	
S1 Economic development	S4 Government policies
S2 Demographic trends	S5 Market incentives
S3 Political stability	S6 Media organizations

Resource system (RS)	Governance system (GS)
RS1 Sector: water	GS1 Government organizations
RS2 Clarity of system boundaries	GS2 Non-government organizations
RS3 Size of water system	GS3 International organizations / donors
RS4 Human-constructed facilities	GS4 Network structure
RS5 Productivity of the system	GS5 Property rights system
RS6 Equilibrium properties	GS6 Operational rules
RS7 Water supply predictability	GS7 Collective choice rules
RS8 Storage characteristics	GS8 Constitutional rules
RS9 Spatial and temporal distribution	

Resource units (RU)	Users (U)
RU1 Resources mobility	U1 Number of users
RU2 Replacement rate	U2 Socioeconomic attributes
RU3 Interaction among units	U3 History of use
RU4 Economic value (water/outpus)	U4 Location
RU5 Number of units	U5 Leadership / entrepreneurship
RU6 Distinctive markings	U6 Norms / social capital
RU7 Spatial and temporal distribution	U7 Knowledge of SES / Mental models
	U8 Dependence on the resource
	U9 Technology used

Interactions (I)	Implementation outcomes (O)
I1 Harvesting levels of diverse users	O1 Promote
I2 Information sharing	O2 Alter/Delay
I3 Deliberation/participation processes	O3 Reverse
I4 Conflicts among users/organizations	
I5 Investment activities	
I6 Lobbying activities	
I7 Self-organizing activities	
I8 Networking activities	

Source: Own elaboration based on Grindle and Thomas (1991) and Ostrom (2007b, 2009).

As reflected in Table 4.2, in terms of SES variables, the reviewed literature on implementation concurs in pointing to a number of variables as relevant factors determining implementation. Thus, political and policy environment factors categorized in variables S3 and S4 determine to a large extent the ease of reform implementation. In addition, the capacity of government organizations (GS1) and the network structure (GS4) are key factors for mobilizing political support. The extent to which the reform affects rules (GS6, GS7 and GS8) is connected to the reactions and responses on both bureaucratic and public arenas. In the case of users, most studies point to socioeconomic attributes (U2) as key variables explaining the capacity of users to affect implementation outcomes. Interaction variables, as those referring to the process of deliberation, participation (I3) and lobbying activities (I6) influence the bargaining process over Law implementation. In addition, information

over water resources is a key factor for planning, controlling and monitoring water uses. Lack of systematic ecological and hydrological information reinforces the barriers for implementation.

Table 4.2 Linkages between factors highlighted in the implementation literature and the SES framework.

Implementation literature		Corresponding SES framework variable
Reference	Factors	
Thomas and Grindle (1990)	Political stability	
	Regime legitimacy	
	Government autonomy	S3
Jouravlev (2001)	Public order problems	
Thanka and Fuller (2010); Wilder (2010)	Democratic transition phase	
Thomas and Grindle (1990); Wilder (2010)	Policy timing with other gov. policies	S4
Araral (2010b)	Media information (alter beliefs)	S6
Thomas and Grindle (1990)	Financial resources	
	Managerial resources	
	Technical resources	
Sabatier and Mazmanian (1980); Hearne and Donoso (2005); Tankha and Fuller (2010); Araral (2010a)	Institutional capacity	GS1
Jouravlev (2001)	Political leadership	
	Proliferation of sectoral organizations	
	Dispersion of responsibilities	
Shah (2007); Wilder (2010)	Donors' requirements	GS3
Thomas and Grindle (1990)	Elite consensus	GS4
Araral (2010a)	Water rights allocation	GS5
Sabatier and Mazmanian (1980)	Implementation legally structured	GS6, GS7 & GS8
Thomas and Grindle (1990) Thanka and Fuller (2010)	Socioeconomic status (groups)	U2
Thomas and Grindle (1990)	Location (groups)	U4
Thomas and Grindle (1990)	Leadership (groups)	U5
Hearne and Donoso (2005)	Mental model of land and water integration	U7
Jouravlev (2001)	Lack of hydro-meteorological information	RS & RU
Hendricks (2009)	Inclusivity & accountability of decision procedures	I2
Tankha and Fuller (2010)	Supply of participation opportunities	I3
Pressman and Wildavsky (1973); Sabatier and Mazmanian (1980); Jouravlev (2001); Shah (2007)	Lobbying activities	I6

In this study, it is argued that some of the factors explaining the delay in the Nicaraguan Law implementation might be connected to the institutional configuration defined in the Water Law. The institutional grammar allows us to identify the legislative emphasis, understand to what extent the new Law modifies the positions and responsibilities of actors, and analyze the relation between the institutional configuration and the responses provided in the interviews. In this respect, we can link these responses to SES variables and institutional statements.

Using the institutional grammar we dissect the Nicaraguan Water Law into three types of institutional statements: rules, norms and strategies (Crawford and Ostrom, 1995). The original syntax of the grammar of institutions contains five components: Attributes (A), Deontic (D), aIm (I), Conditions (C) and Or else (O). In addition, following Siddiki *et al.* (2011), we include an additional element: the oBject. In the following lines, the six components are broadly defined. However, exhaustive definitions can be found in Crawford and Ostrom (1995), Basurto *et al.* (2010), and Siddiki *et al.* (2011).

The Attribute defines to whom the institutional statement applies (e.g. individual, group of individuals, organization, etc.). The Deontic is the prescriptive operator and indicates whether the action is permitted, obliged or forbidden (e.g. may, must, must not, etc.). The aIm refers to the action contained in the statement and to which the Deontic applies, it usually consists of all non-Deontic verbs in the statement. Conditions determine under which circumstances the statement is appropriate or relevant for application (e.g. "when", "where", "how"). The Or else element includes the punitive action for not following the rule. The oBject code, developed by Siddiki *et al.* (2011) with the objective of reducing some of the ambiguities when interpreting institutional statements, refers to the part of the statement upon which the Attribute is acting. Thus, the oBject is the receiver of the action. For coding purposes we have distinguished between explicitly and implicitly stated attributes, deontic and conditions in the units of analysis.

Based on these elements, strategies are defined as institutional statements that include only the Attribute, aIm and Conditions (AIC/ABIC); norms include the Attribute, Deontic, aIm and Conditions (ADIC/ABDIC) and rules additionally incorporate the Or else operator (ADICO/ABDICO). The distinction among different types of institutional statements enables us to identify which actions are prescriptive, who are the Attributes (individual or corporate actors) supposed to carry out a particular aIm, the prerequisites or restrictions that apply to particular activities and the type of sanctions for noncompliance (Siddiki *et al.*, 2011). The seriousness of the Deontic and the incorporation of the Or else operator determine the changes in the payoffs perceived and the sanctioning process. Sanctions through the Or else require monitoring and the existence of a norm or rule regarding the duties and rights of the monitor (Schlüter and Theesfeld, 2010).

4.4   Research methodology

In this study, we first examine the social-ecological water system of Nicaragua based on the variables defined in Figure 4.1 and Table 4.1. Secondly, using data gathered from 40 guided in-depth personal interviews, we code the factors mentioned in the interviews regarding the barriers for law implementation along the second-tier variables defined in Table 4.1. Thirdly, we link the factors mentioned in the interviews to the institutional statements coded in the Nicaraguan Water Law.

Personal interviews were held in July and November 2009. We specifically selected individuals who have held key positions at the national level within the water sector as decision-makers, consultants or representatives of an interest group in the period from 2003 to 2009. This period includes the new Water Law drafting process and initial implementation stage. The sample includes the following types of actors: 28 represented public organizations, 4 belonged to civil organizations, 5 to international organizations, 2 to academia and 1 to a farmers' union. Subjects in public organizations were chosen according to the responsibilities granted by the water and other sectors' legislation. Document analysis (e.g., see Gómez *et al.*, 2007) provided further information on the key actors. Subsequently, "snowball" sampling was used to broaden the original list[6].Interviewees were previously reached through e-mail with a presentation letter indicating that the purpose of the interview was to gather information on the factors that may hinder or delay the Water Law implementation in Nicaragua. The purpose was not to guide the interview along the SES framework, but to connect the findings to the framework subsequently.

Most of the actors interviewed belonged to public organizations. The logic behind this selection bias is that both sectoral laws and new Water Law grant most responsibilities to government organizations. In addition, although the Water Law creates new bodies, most ministries and sectoral organizations take part in these newly created organizations.

Interviews were transcribed, coded and tabulated based on the set of conceptual variables defined in Table 4.1. Interviews were coded and analyzed using the qualitative research software HyperResearch 2.8.3, which enabled us to retrieve code frequency tables. The research software allowed us to assign second-tier SES variables to specific parts (i.e. sentences or paragraphs) of the interview. In a similar way, the Nicaraguan Water Law has been dissected into the elements of the institutional grammar tool. For this coding, we used the guidelines developed by Basurto *et al.* (2010) and Siddiki *et al.* (2011). Overall, we divided the Nicaraguan Water Law into sentence-based units of observation and coded each unit of observation following the ABDICO syntax. Afterwards, we coded all units as rules, norms, or strategies (for an example, see Appendix 1).

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[6] A snowball sample consists of asking a participant to suggest another person who might be a willing or appropriate study participant.

4.5   The new Nicaraguan Water Law

The 1987 Nicaraguan Constitution considers natural resources as public domain and grants the government the competences to regulate its allocation and uses. The national Water Policy was enacted within this legislative framework in 2001 (La Gaceta, 2001), establishing a number of guiding principles that were taken up again in the new Water Law and are summarized in Table 4.3.

Table 4.3 Nicaraguan Water Policy characteristics.

Policy characteristics
1. Recognizes Dublin principles
2. Water: public domain, owed by the state and strategic resource
3. Human consumption: priority use
4. Preservation & prevention criteria: project selection based on economic, social and environmental criteria
5. Polluter-pay and user-pay principles
6. Proposes the development of a water rights and transfer system
7. Motivated by the Environmental and Natural Resources Law

Source: Own elaboration based on La Gaceta (2001).

As foreseen in the Constitution, the new Water Law regards water as public domain and proposes a decentralized model for water management based on a National Water Authority (ANA) and River Basin Organizations (RBO). The ANA would be in charge of regulating, administrating, monitoring and controlling water resources, with RBOs operating under the ANA's umbrella. The National Water Resources Council (CNRH) would be responsible for supervising the ANA and updating the water policy. The ANA and RBOs are in charge of developing national and river basin plans, respectively.

Regarding water allocation, concessions and licenses are granted by the ANA for large water and sanitation systems as well as for hydropower and agricultural purposes. In the case of small water systems or agricultural holdings smaller than 70 ha, local governments could also grant authorizations if they have previously signed a collaboration agreement with the ANA. Similarly to water laws all over the world, providing drinking water tops the list of priorities.

The financial scheme of the water sector represents one of the most relevant and complex aspects of the new Water Law. The National Assembly should pass a Water Tariff Law based on the ANA's economic valuation of water resources. The funds would be used to support the National Water Fund (FNA) with the objective of financing water programs and activities related to both water policy and plans. As of 2012, no legislative initiative to regulate water tariffs has been submitted to the National Assembly.

Overall, the principles of the new Nicaraguan Water Law correspond to a standard and modern water law, as defined in Caponera (1992) and Embid (2008).

4.6 Social-ecological water system in Nicaragua

In this section, we characterize the variables defined in our analytical framework as reported in Figure 4.1. This provides a baseline for the analysis of interviews and explains some of the reactions to the implementation of the new Water Law.

4.6.1 Social, economic and political setting (S)

Nicaragua is classified as a lower-middle income country and ranks 129th among 187 countries in the Human Development Index (UNDP, 2013). The net official development assistance received has traditionally represented more than 10% of the Gross National Income (World Bank, 2013). Therein lies the importance of international and development agencies in triggering some of the major institutional and regulatory reforms undertaken in the country. In terms of demography, most of Nicaragua's population is concentrated in the Pacific region, and urban and rural populations account for 56 and 44 percent of the total population, respectively (World Bank, 2013).

With respect to political stability, the last several decades Nicaragua saw three major political regimes: the Somoza dictatorship, which lasted from 1937-1979, followed by the Sandinista government, in power from the revolution in 1979 to 1990, followed by the Chamorro and liberal governments, in power from 1990 to 2006. In 2006, the Sandinistas regained power through the polls and retained control of the government after November 2011 election.

During the Somoza period (1937-1979), the vertically controlled political system favored patron-client relationships that resulted in a lack of access to basic services and opportunities for the majority of the population, especially in rural areas (Donahue and McGuire, 1995; Hawkesworth and García-Pérez, 2003). Agro-export booms in the late 19th century were associated with land appropriations by politically well-connected individuals (Deininger*et al.*, 2003). The Sandinista Revolution of 1979 attempted to democratize the country by developing several social programs and enacting the 1981 Agrarian Reform Law. However, by the end of 1989, the standard of living was well below the level of the late 1970s (Brown, 1996), partly as a result of the Contra-Sandinista war that ended with the Esquipulas Peace Agreements in 1989. Furthermore, the land titles given by the Sandinistas' land reform had not been transferred to state ownership prior to being redistributed. As a result, despite the efforts in overcoming its unequal land distribution, Nicaragua still faces a remarkable land titling and distribution problem.

In the 1990s, the Chamorro government redirected economic policies toward a neoliberal model, launching several phases of agriculture, infrastructure, and service privatization (Estache and Trujillo, 2008). The subsequent administrations of Alemán (1997-2002) and Bolaños (2002-2007) intensified the privatization of both land and corporations. In addition, reconstruction needs after Hurricane Mitch in

1998 prompted the Nicaraguan government to request reconstruction funds from international donors, some of which were tied to structural reforms. In that context, in 2001, the Nicaraguan government attempted to grant exclusive management of one of the country's major hydroelectric plants. Grassroots groups supported by the Sandinista party stood against privatization, which succeeded in pushing Law 440 through the legislature, stopping all privatization attempts until a water regulatory framework was enacted (La Gaceta, 2003). The first government Water Law draft was presented in 2002, followed by two other versions presented at the National Assembly by the National Consumers Defense Network (RNDC) and the Anti-privatization and Water Right Access Alliance (CODA). The Water Law was passed on February 2005, afterwards the first 45 articles were approved on November 2006 and, finally, on May 2007 the Water Law was enacted at the National Assembly.

4.6.2   *Governance system (GS) and users (U)*

When considering the Nicaraguan water governance system, two aspects should be highlighted: first, the current dispersion in the water sector administration within the government and, second, the water and sanitation bias reflected in the number of actors devoted to managing and financing this sub-sector. Based on the competences assigned by water sectoral laws, Figure 4.2depicts the existing complexity and fragmentation, with multiple institutions connected to different spatial and use dimensions of water resources. In Figure 4.3, the new water sector framework is represented according to the roles and functions defined in the 2007 Water Law.

As shown in Figure 4.2, prior to the passing of the Water Law the government's main roles were to regulate, plan and manage water resources. Overall, four main public organizations were in charge of the water and sanitation sector in the pre-Water Law period: the National Commission on Water and Sanitation (CONAPAS), the policy design body; the Nicaraguan Institute for Water and Sanitation (INAA), in charge of regulatory functions; the National Water and Sanitation Company (ENACAL), with the main objective of providing potable water and sanitation services in urban areas; and the Social Emergency Investment Fund (FISE), responsible for the rural sector (World Bank, 2008). However, when considering the water sector jointly, more than ten public organizations took part in water sector management.

Actor	Water organization	Water use				Key role					Spatial scale	Local	
		Agriculture	Environment	Energy	Drinking & sanitation	Regulatory	Planning & management	Conflict resolution	Pricing & financing	Consult & research	National	Urban	Rural
Government (GS1) — Ministry	MARENA	■	■	■	■	■	■	■			■		
	MAGFOR	■	■			■	■				■		
	MINSA				■	■					■		
	MIFIC	■		■		■					■		
	MEM			■		■					■		
Government (GS1) — Autonomous government body	INAA				■	■					■		
	ENACAL				■		■		■			■	
	ENEL			■							■		
	INETER									■	■		
	INTA	■									■		
	FISE				■		■		■		■		■
	CONAPAS				■		■				■		
	CNRH						■				■		
	Local Gov.	■	■	■	■	■	■					■	
	Reg. Gov.	■	■	■	■	■	■				■	■	
	Courts	■						■			■		
	Env. Att.		■					■			■		
	Police		■								■		
	Nat. Assem.	■	■	■	■	■					■		
Int.Com. (GS3)	Inter. Banks			■	■				■		■		
	Dev. Ag./NGO		■		■		■	■			■		
Civil org. (GS2)	Nic. NGOs	■	■		■		■					■	■
	CAPS				■		■						■
	Mun. Assoc.						■			■			
	Basin Comm.	■	■	■	■								
	Farm. Unions	■								■			■

Figure 4.2 Organizational mapping before the Nicaraguan water law implementation.

Note: MARENA = Environment and Natural Resources Ministry; MAGFOR = Agriculture and Forestry Ministry; MINSA = Health Ministry; MIFIC = Infrastructure and Trade Ministry; MEM = Energy and Mines Ministry; INAA = Nicaraguan Institute for Water and Sanitation; ENACAL = National Water Supply and Sanitation Company; ENEL = Nicaraguan Electricity Company; INETER = Institute Territorial Studies; INTA = Institute of Agricultural Technology; FISE = Social Investment Fund; CONAPAS = Commission on Water and Sanitation; CNRH = National Water Resources Commission; Reg. Gov. = regional governments; Env. Att. = environmental attorney; Nat. Assembly = National Assembly; Int. Com. = international community; Inter. Banks = international banks; Dev. Ag. = development agencies; Civil org. = civil organizations; Nic. NGOs = Nicaraguan NGOs; CAPS = water and sanitation committees; Mun. Assoc. = municipal associations; Basin Comm. = Basin Committees; Farm. Unions = Farmers' Unions. Source: Own elaboration based on sectoral regulations.

At the national level, ministries and institutes are the major actors, whereas at the local level, regional governments play a more relevant role. In the new institutional framework, as shown in Figure 4.3, local and regional governments take part in both basin agencies and basin committees.

Actor	Water organization	Water use				Key role					Spatial scale		
		Agriculture	Environment	Energy	Drinking & Sanitation	Regulatory	Planning & management	Conflict resolution	Pricing & financing	Consult & research	National	Local (Urban)	Local (Rural)
Government and non-government (GS1, GS2)	CNRH[a]	▩	▩	▩	▩		▩				▩		
	ANA	▩	▩	▩	▩	▩	▩				▩	▩	▩
	RNDA	▩	▩	▩	▩		▩				▩		
	RBO[b]	▩	▩	▩	▩		▩					▩	▩
	FNA								▩		▩		
	Basin[c] Com.	▩	▩	▩	▩					▩		▩	▩
		▩	▩	▩	▩							▩	▩
		▩	▩	▩	▩							▩	▩
		▩	▩	▩	▩							▩	▩
		▩	▩	▩	▩							▩	▩
	Irrigation districts	▩					▩						▩

Figure 4.3 Organizational mapping according to Nicaraguan Water Law.

Note: CNRH = National Water Resources Council; ANA = National Water Authority; RNDA = Water Rights Registry Office; RBO= River Basin Organizations; FNA = National Water Fund; Basin Committ. = basin committees. [a]CNRH is composed of representatives from Environment and Natural Resources Ministry (MARENA), Agriculture and Forestry Ministry (MAGFOR), Health Ministry (MINSA), Infrastructure and Trade Ministry, Institute Territorial Studies (INETER), Nicaraguan Institute for Water and Sanitation, Energy Administration (INE), Commission on Water and Sanitation, regional governments, and civil population. [b]River Basin organizations are composed of representatives from ANA, MARENA, municipal majors, INETER, MAGFOR, and MINSA. [c]Basin Committees are composed of representative from users, CPC (Citizen Power Councils), RBO, regional and local governments and NGOs. Source: Own elaboration based on Nicaraguan Water Law.

Drinking water and sanitation in rural areas is mostly supported and funded by international organizations, aid agencies, NGOs and FISE and operated by Water and Sanitation Committees (CAPS). CAPS are water user organizations created by the local population that provide water services to rural communities. However, under the new organizational framework, ENACAL is also responsible for the rural water sector. In addition to the new responsibilities granted to ENACAL, there is an underlying competence conflict between ENACAL and INAA. Whereas Law 275 granted regulatory functions to INAA, the new Water Law does not clarify whether INAA or ENACAL is the regulatory body for the water and sanitation subsector. Nevertheless, for the time being, the rural water sector is mostly operated by CAPS.

Because most water conflicts occur at the local level, both local governments and ministry and environmental attorney offices are the major actors involved in conflict resolution, as shown in Figure 4.2. The new Water Law grants conflict mediation functions to the ANA. How effectively this conflict-resolution responsibility will be delivered remains to be seen.

With respect to water financing, international donors and development banks are responsible for the lion's share of water funding. Jointly with government and civil organizations, international donors form the Water and Sanitation Board, whose objective is to coordinate financial cooperation and investments in the water sector. However, the new institutional setup does not reflect, at least explicitly, the position of these major water funders. The new institutional mapping brings along water financing and pricing for agriculture. Thus far, water for agriculture is not priced and is used as a more or less open access resource.

Based on the comparison of institutional maps, the new Water Law attempts to simplify the distribution of competencies and roles among the government branches. However, because the new agencies have not actually been put in place, the interim standing of the government roles reinforces the barriers to change and provides time for strategic actions.

4.6.3 Characteristics of the Water System and Resource Units (RS, RU)

Water resources in Nicaragua are characterized by an uneven distribution in both space and time (INETER, 2010). Total fresh water withdrawals amount to 1.3 km³/yr, of which agricultural, industrial and domestic use account for 83%, 2% and 15%, respectively (FAO, 2010). The main irrigated crops are cereals, mostly maize, vegetables and sugar cane. Water is also used in the wet processing of coffee, which is one of Nicaragua's major export crops. Primary crops contribute to nearly 40% of Nicaraguan exports (BCN, 2010) and agriculture value added account for nearly 20% of GDP (FAO, 2010).

Nicaragua lacks a systematic spatial and temporal water database, which makes it complicated to estimate the productivity of the system and the predictability of the water supply. In this sense, some of the new Water Law and policy principles and mechanisms (e.g., cost recovery, water markets, water tariffs, etc.) seem rather inapplicable without an information and control system supporting them.

A general factor that has been introduced by the Water Law is water pricing. Currently, water for purposes other than urban domestic uses is not priced, which, in turn, affects variables such as the productivity of the system, water availability and the economic value of output. In addition, as the new Law approaches water management from an integrated and river basin perspective by introducing river basin organizations and irrigation districts, the way in which units interact with each other (e.g., irrigation units within the system) is also likely to change.

4.7   Empirical results

4.7.1   *What factors do policy actors identify that delay the implementation process of the Nicaraguan Water Law?*

Results are organized according to the SES framework presented in Figure 4.1 and Table 4.1.Interviews' coding allows us to identify second-tier variables that policy actors consider to be constraints on the implementation of the new Water Law. Table 4.4 summarizes the variables with a response's frequency higher than 6 as the median is equal to 5.5.

A major factor stressed in the interviews is the relevance of informal politics in the political arena. This is represented by the variable "Hybrid" regime (S3a) and makes reference to the fact that Nicaraguan political regime combines both democratic and authoritarian elements (Diamond, 2002). Interviewees from civil and international organizations note that politics have a large influence on government technical decisions and that the influence of a government organization depends to a large extent on the person who holds its directorship (GS1e).

Another barrier relates to the fact that decision making power is highly centralized (GS1b). Although the new Water Law attempts to decentralize management by introducing river basin organizations, most decisions are in fact centralized at the government's offices in the nation's capital. In contrast, local governments remain unpowered despite their assigned responsibilities over territorial development and water management (GS1c, GS1d) (Larson, 2002). Some interviewees also considered that the responsibilities assigned to ANA are too broad and, therefore, the ANA might not be fully operative in the short term (GS1f). The lack of human capital in both national and local government organizations is also considered as one of the limitations (GS1a). In some cases, this might be related to the high turnover rate of personnel, as expressed by an interviewee from an international organization.

The lack of monitoring activities (GS6a) appears as a factor constraining implementation and enforcement. Monitoring is also linked to information and, as mentioned in the previous section, Nicaragua lacks a systematic water database. As acknowledge by 8 interviewees, out of whom 7 corresponded to public actors, there is a limited level of information flows and coordination among government organizations (I2b).

One of the major factors identified in the interviews is the fuzzy definition of competences in the new Water Law (GS8b). This leaves room for conflicts of competences among government organizations at national and local levels (I4c). In particular, actors from government, non-government, international organizations and academia recognize that responsibilities for water concessions and authorizations are not clearly defined in the Law. In addition, sectoral regulations both at the central and local levels have not been harmonized (GS7a) with the new

Water Law, which may contribute to conflicts of competence among government organizations (I4d). This is particularly evident between INAA and ENACAL in the case of the water and sanitation subsector, as mentioned in section 6. As long as sectoral regulations are not aligned with the new Water Law, different collective-choice rules about who may participate and change the operational rules coexist (e.g., for water management at the irrigation district level and drinking water systems), which may complicate advances in implementation.

Table 4.4 Factors identified in the interviews as influencing Water Law implementation.

Socioeconomic and political setting (S)	
S3 Political stability (14)	
S3a Hybrid regime (14)	
Governance system (GS)	
GS1 Government organizations (44)	GS6 Operational rules (8)
GS1a Lack human capital (9)	GS6a No monitoring activities (8)
GS1b Centralized decision-making (9)	GS7 Collective choice rules (13)
GS1c Unpowered local government (10)	GS7a Sectoral rules not harmonized (13)
GS1d Local gov. important actors (3)	GS8 Constitutional rules (25)
GS1e *Personalism* and politicized (9)	GS8a No "water rules" before WL (3)
GS1f ANA too big & not operative (4)	GS8b Fuzzy competence definitions in WL (17)
GS5 Property rights system (8)	GS8c WL oriented to water & sanitation (5)
GS5a Land & water managed as private (4)	
GS5b Many farmers not titled (4)	
Resource units (RU)	**Users (U)**
RU4 Economic value (water/outputs) (8)	U2 Socioeconomic attributes (13)
RU4a No water tariffs (4)	U2a Economic & political power of
RU4b Price volatility (2)	agricultural elites & private companies (13)
RU4c Energy production (2)	
Interactions (I)	
I2 Information sharing (13)	
I2a Low Water Law diffusion (5)	
I2b Lack of information flows (8)	
I3 Deliberation/participation processes (7)	
I3a Long and politicized process (3)	
I3b Participation of foreign and external consultant (2)	
I3c Participation mainly organized by civil society organizations (2)	
I4 Conflicts among users/organizations (25)	
I4a Among uses (agriculture vs. human consumption / agriculture vs. energy) (13)	
I4b Between executive and legislative powers (1)	
I4c Local and national levels (2)	
I4d Government org. (INAA – ENACAL) (6)	
I4e Interest conflicts (economic – political) (3)	
I6 Lobbying activities (19)	
I6a Agricultural elites & private companies (14)	
I6b Lack civil society & local governments pressures (5)	

Note: Factor's frequency (number of individual cites out of 40) between brackets.
Source: Own elaboration based on interviews' data.

Some respondents also argued that the new Water Law pays more attention to water and sanitation than to other uses (GS8c), such as agriculture, despite the fact that

most water conflicts occur between agriculture and human consumption or agriculture and energy uses (I4a). Interviewees indicated that most participatory processes during the Law-drafting stage were organized by civil organizations concerned with the human right to water (I3c). This is, to some extent, connected to the responses from consumer and anti-privatization groups after the government's attempt to privatize a hydroelectric plant, as discussed in the previous section.

Another aspect to take into account relates to the economic and political power of agricultural elites and private companies (U2a). Interviewees from public, international and civil organizations recognize that large landowners and private companies oppose the passage of a new Water Law regulating water tariffs (RU4a), as the water sector has traditionally operated without formal rules on how charges should be set (GS8a). In addition, water, in particular for agriculture, has been mostly managed as a private resource linked to land (GS5a). The interaction results also show that there are economic and political conflicts of interest (I4e) in establishing some of the Water Law principles, as powerful groups representing sugarcane mills and the rice and coffee industries have a presence in the National Assembly. In addition, agricultural production is linked to the use of sugarcane by-products for energy production (RU4c). In this sense, water and agriculture play an important role in the country's energy strategy, which may place sugarcane landholders in a strategic position.

In the Nicaraguan case, grassroots groups played an important role in triggering water sector reform, moving from an opposing to a proposing position. However, once the new Water Law was passed, lobbying activities have been carried out chiefly by private companies (I6a), with less involvement from civil society (I6b). Most civil society efforts have been concentrated in the water and sanitation sector.

4.7.2 *Linking perceptions to the Nicaraguan Water Law content*

In the following paragraphs, we show that some of the barriers identified throughout the interviews might be linked to the institutional configuration that stems from the Nicaraguan Water Law. Table 4.5 presents the data as the coded units of observation by Water Law Title.

The total number of institutional statements in the Law amounts to 190, out of which 79 correspond to strategies (AIC/ABIC) and 111 to norms (ADIC/ABDIC). Surprisingly, we found zero rules (ADICO/ABDICO) in the Water Law, despite the fact that Title IX deals with sanctions. This is consistent with findings in past applications of the Institutional Grammar (Basurto *et al.*, 2011). The ANA is the authority in charge of sanctioning. However, this responsibility is not included within ANA functions, as defined in Title III. Title IV of the Law, regulating water rights, concentrates most institutional statements. It is followed in number by Title III that defines the water administration system.

Table 4.5 Summary of Institutional Statements as Number of Units of Observation by Water Law Title.

Unit of observation	Water Law Title										Total
	TI	TII	TIII	TIV	TV	TVI	TVII	TVIII	TIX	TX	
Number of strategies	1	5	11	20	7	9	3	2	6	15	79
Number of norms	5	8	17	19	14	6	19	6	6	11	111
Number of rules	0	0	0	0	0	0	0	0	0	0	0
Total number of units of observation	6	13	28	39	21	15	22	8	12	26	190

Note: TI: Law scope; TII: Principles, management tools & hydrological planning; TIII: Water administration; TIV: Water uses; TV: (Sector) water uses; TVI: Economic regimen; TVII: Water protection; TVIII: Investment in hydraulic infrastructure; TIX: Sanctions; TX: Final provisions.

Barriers related to government organizations (GS1) were widely recognized in the interviews. In this respect, Table 4.6 shows that ANA has been grated most technical and regulatory responsibilities regarding Water Law implementation. Most of them have been granted in the form of strategies, which implies, in the institutional grammar sense, that there are not normative considerations or external sanctions for non-compliance. The perception that the responsibilities assigned to the ANA are too large and therefore that the ANA might not be operative (GS1f) could be explained by the low ratio between budget allocation and number of tasks assigned to the ANA.

Table 4.6 Configuration of the water administration system in the Water Law.

Attribute	Institutional Statement		Frequency
CNRH	Norm	ADIC/ABDIC	9
ANA	Norm	ADIC/ABDIC	3
	Strategy	AIC/ABIC	30
RBO	Norm	ADIC/ABDIC	1
	Strategy	AIC/ABIC	1
RBC	Norm	ADIC/ABDIC	1
	Strategy	AIC/ABIC	2
RPNDA	Norm	ADIC/ABDIC	2
	Strategy	AIC/ABIC	1
Reg. /Local gov.	Norm	ADIC/ABDIC	1
	Strategy	AIC/ABIC	1

Note: CNRH = National Water Resources Council; ANA = National Water Authority; RBO = River Basin Organizations; RBC = River Basin Committees; RNDA = Water Rights Registry Office; Reg./Loc. Gov. = regional/local governments.

According to the Water Law, ANA's tasks can be decentralized toward river basin organizations (RBO). In this line, two institutional statements refer to RBO, whereas 33 to the ANA. The ANA can then transfer some or all of its responsibilities to the RBO. However, to date, no RBO has been put in place and most decision-making processes are still centralized in the hands of ANA and ministry offices (GS1b).

Local governments are the Attributes in two institutional statements referring to the task of granting water authorizations when they have firstly signed a collaboration agreement with the ANA. Mayors from the municipalities included within a river basin take part in RBO's board. Thus, they might have more power over water issue decisions when they can bargain in the board sessions and the ANA has transferred specific responsibilities to RBOs. These results are in line with the perception that local governments remain unpowered despite their important role in land planning and territorial development (GS1c, GS1d), as recognized in the Municipality Law.

Three types of aIms fall in the hands of political institutions: (i) appointing ANA's director; (ii) ratifying water rights for large impact, multiple or strategic uses and (iii) enacting Water Tariffs Law. These actions have to some extent a political dimension which might interact with the influence of informal politics in more technical decisions, as recognized by some interviewed actors (GS1e).

The water sector in Nicaragua has mainly operated without formal water rights (GS8a). In addition to developing a water rights system, the new Law introduces price mechanisms through water tariffs (RU4a). Both the Tariff Law proposal and approval are strategies, which means that have nothing of a prescription, but describe the behavior of actors. The ANA is in charge of proposing water tariffs to the Assembly, which is responsible of its enactment.

The configuration analysis shows that, in particular, basin management, drinking water provision and the National Water Fund are to be regulated by specific regulations. The institutional statements describing these three activities are strategies (AIC/ABIC), which might increase the potential for delay on carrying out these tasks, given that they do not include any kind of prescription (GS8b). In addition, due to the delay on the Water Law implementation, sectoral regulations coexist with the Water Law (GS7a), creating multiple collective-choice rules on paper, which might take different forms on the ground.

Regarding the institutional statements devoted to water uses, Table 4.7shows that, apparently, both drinking water and agriculture receive similar attention in the Water Law. Nevertheless, the Water Law recognizes the right to water in its principles (Title II), which to a certain point might explain the major focus on drinking water and sanitation provision (GS8c).

Table 4.7 Institutional statements by water use in Title V of the Nicaraguan Water Law.

Water use	Institutional statement		Frequency
Drinking water	Norm	ADIC/ABDIC	4
	Strategy	AIC/ABIC	1
Agriculture	Norm	ADIC/ABDIC	3
	Strategy	AIC/ABIC	3
Energy	Norm	ADIC/ABDIC	5
Ecosystems conservation	Strategy	AIC/ABIC	3
Others	Strategy	ADIC/ABDIC	2

4.8   Conclusions

The Nicaraguan case illustrates the types of difficulties that developing countries face in implementing water reforms. By linking the perceptions of 40 actors involved in the Nicaraguan Water Law process along SES variables, this article finds that major barriers are related to power configuration within the water social-ecological system, which creates conflicts of competences within government and at local and national levels. Our research suggests that decision-making is highly centralized, whereas local governments remain unpowered despite their relevant role in water management.

The application of the institutional grammar shows that most tasks are concentrated in the National Water Authority in the form of strategies, which describe a type of action but do not include any prescription element. As suggested by Siddiki *et al.* (2011), policies are often viewed as prescriptions which are assumed to be enforceable by some agents. However, our results suggest that intended changes of institutions proposed in the Water Law (e.g. water rights and water tariffs) are prone to generate opposition from powerful groups, in particular large owners of agricultural holdings and private companies, with the capacity and incentives to hinder instead of promoting advances in the law process.

The SES framework applied in this study considers the interactions that result from the social and ecological system and that may contribute to explaining implementation outcomes. The Nicaraguan case highlights the relevant role of information flows among government organizations, as well as the influence of politics in deliberation and participation processes. Furthermore, although ecological aspects have been barely mentioned along the interviews, the descriptive analysis of the Nicaraguan water system reflects relevant dynamics linked to the property rights structure, the prevalence of groundwater systems and the lack of information needed for putting into practice many of the tasks included in the Water Law.

The SES framework and approach used in this study provides an integral perspective to the analysis of environmental reforms, in which social and ecological systems are deeply interrelated and embedded within the broader political and economic context.

The institutional grammar tool complements the analysis by dissecting the reform according to the ABDICO syntax. This allows us to link policy actors' perceptions to the institutional configuration of the Water Law and to understand to what extent this configuration attempts to modify the formal and informal institutions that are in place, which ultimately defines political and economic power distribution and reactions to the reform.

5 Social capital and collective irrigation: Evidence from informal irrigation systems in Nicaragua

Abstract

This chapter presents an analysis of the effects of social capital and community participation in collective action for irrigation in the Upper Rio Viejo Sub-basin, Nicaragua. A two-stage econometric estimation procedure, consisting on a binary probit and logit regression, is applied to primary data collected through a household survey on a sample of 121 households. The research attempts to provide clues about what makes communities and individuals more willing to participate in irrigation districts, which the Nicaraguan Water Law aims at creating in the rural areas. Regression results indicate that the intensity of social networks, the type of agents willing to provide social support and the level of trust in the community are all significant factors in explaining collective action at community level. Surprisingly, participation in community meetings was found negatively related to collective action for irrigation. The fact that most collective irrigation relies on family ties suggests that critical social capital variables might be defined within the family and difficult to go beyond it. We also find that collective irrigation is more likely when there is a canal system and that farmers located nearby the riverside are less likely to engage in collective systems. These results highlight the importance of the origin of the collective action and the preference for individual action given the current structure of incentives.

Publications

- Novo, Paula, Alberto Garrido, and Ruth Meinzen-Dick. 2011. Challenges in getting off the ground the new Nicaraguan Water Law: from farmer groups to formalized irrigation districts? *13th Biennial Conference of the International Association for the Study of the Commons.* 10-14 January 2011, Hyderabad, India.
- Novo, Paula, and Alberto Garrido. 2011. Testing hypothesis on social capital and irrigation organization: The case of the Upper Rio Viejo Sub-basin. *XIVth IWRA World Water Congress.* 25-29 September 2011, Recife, Brasil.
- Novo, Paula, and Alberto Garrido. 2011. Informing irrigation districts development in Nicaragua: challenges from a social capital and collective action perspective. *European Associaton of Agricultural Economists 2011 Congress.* 30 August – 2 September, Zurich, Switzerland.

5.1 Introduction

The Dublin Statement (1992) on Water and Sustainable Development put forward four guiding principles for an integrated water resources management. With a view to foster increased efficiency, equity and democratization, the second principle establishes that "Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels"[7]. This argument involves a certain degree of collective action and cooperation among stakeholders. In this respect, a large body of literature on natural resources management has been devoted to identify the factors that influence collective action in the commons and the conditions under which cooperation is maintained (Anderies *et al.*, 2004).

This study examines the case of Nicaragua, where the new Water Law, enacted in September 2007, represents the first attempt for putting into practice the principles of integrated water resources management. The new Water Law introduces the concept of irrigation districts and defines them as the territorial area around which farmers might organize for better water, land and infrastructure management. However, establishing formal irrigation institutions is not a straightforward task in countries with little collaborative experience and weak government's leadership. As discussed in Meinzen-Dick (2007), over the past 50 years a wide range of institutional arrangements have been proposed as panaceas for irrigation. But, institutional designs implemented from similar founding bases have displayed different outcomes depending on the specific local context. Overall, whether or not a process as the Nicaraguan irrigation development occurs smoothly is closely linked to the structure of incentives that farmers perceive. These incentives might not only be related to economic and environmental factors, but also to the cultural and social characteristics of the resource users.

The literature about social capital has stressed the relations between social norms and collective action for public goods provision (Coleman, 1990; Putnam, 1995; Pretty and Ward, 2001; Pretty, 2003; Krishna, 2004; Meinzen-Dick *et al.*, 2004; Motiram and Osberg, 2010). As collective irrigation involves the provision of public goods, it is relevant to consider the effect of social capital factors on the decision to participate in collective irrigation organizations. Cox *et al.* (2010) identified that one of the primary critiques to Ostrom's (1990) institutional design principles for community-based natural resource management is the lack of attention to critical social variables, such as trust, legitimacy and transparency.

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[7] Principle 1: Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. Principle 3: Women play a central part in the provision, management and safeguarding of water. Principle 4: Water has an economic value in all its competing uses and should be recognized as an economic good.

This study seeks to analyze the effect of social capital on collective irrigation in the upper Rio Viejo sub-basin (North Nicaragua). For this purpose, we implemented a survey in 8 communities where irrigation is mostly concentrated, including a total sample of 121 households. The research focuses specifically on collective action and explores its link to both structural and cognitive social capital. This study attempts to test whether social capital facilitates participation in activities at community level which, in turn, influences the decision to participate on collective irrigation systems. For this purpose, a two-stage econometric estimation procedure is applied to the collected data. The analysis of these results may provide relevant insights for the development and formalization of irrigation groups into irrigation districts.

The rest of the chapter is organized as follows. Section 5.2 discusses the conceptual framework and section 5.3 describes the methods used in this study. Section 5.4 describes the study area and data collection methods. Section 5.5 and 5.6 contain the major findings and conclusions, respectively.

5.2   Conceptual framework

Theories of collective action explain individual behavior in a group when there is a potential conflict between the individual and the common interests (Ostrom and Ahn, 2009). First-generation collective action theories assume that individuals are selfish and fully-rational and, therefore, the common interest would not be achieved without the external intervention of either the government or the market (Olson, 1965; Hardin, 1968). However, a large number of studies find that, in some cases, individuals are able to self-organize and overcome collective action problems (Poteete *et al.*, 2010). Key factors related to the attributes of the resource itself, such as scarcity and size, the resource users, like heterogeneity, age and origin of the group and proximity to markets and the socioeconomic and institutional context have been identified as determinants of collective action in managing the commons (Agrawal, 2001; Meinzen-Dick*et al.*, 2002; Poteete and Ostrom, 2004; Araral, 2009, among others). In addition, the social capital approach stresses the effect of trustworthiness, networks and formal and informal rules on the capacity of communities to solve collective action problems (Meinzen-Dick *et al.,* 2004; Bodin and Crona, 2008; Ostrom and Ahn, 2009).

Putnam (1995, p.67) refers to social capital as the "features of social organizations such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit". Pretty and Ward (2001) identify four key aspects related to social capital: 1) trust; 2) reciprocity and exchanges; 3) common rules, norms and sanctions and 4) connectedness, networks and groups. These four aspects are often inter-connected. As found by Krishna (2004), responses related to group membership, trust, solidarity and reciprocity are highly correlated. Trust may facilitate cooperation while lowering transaction costs (Fukuyama, 1999). Grootaert and Narayan (2004), in their study in Bolivia, recognize the contribution of local social capital to household welfare, in particular, for the poor. In this line, Carter and

Castillo (2011) show that trustworthiness and altruistic sharing norms play an important role in increasing living standards in South Africa.

Experimental research on collective action has shown that some individuals behave as "strong reciprocators", responding to both intrinsic preferences and pecuniary payoffs (Ostrom, 2005b). When individuals interact in repeated situations and are able to identify the behavior of their peers, those who follow a trustworthy fair reciprocator behavior achieve better material outcomes than the rational egoists (ibid.). As argued in Pretty and Ward (2001), reciprocity contributes to the development of long-term relationships between people which, might have a positive effect on environmental outcomes.

Cavalcanti *et al.* (2013) show that the level of social integration is related to cooperation in common pool resources management. Social capital factors might facilitate access to information and increase the probability of participating in collective initiatives (Willy and Holm-Müller, 2013). Nevertheless, Motiram and Osberg (2010) conclude that the effect of social capital on development depends on the specific historical context. Thus, for the case of India, these authors find that the time spent in social interactions reinforce existing social norms, undermining other forms of collective action that might improve overall community well-being.

Efforts to create grass-roots collective entities must be focused on groups and individuals that have shown some inclination to cooperate and have had positive experiences from cooperation (Meinzen-Dick *et al.*, 2004). As suggested by Fujiie *et al.* (2005), willingness to cooperate is greater in individuals who have cooperated in the past, and have obtained rewards from that cooperation. Furthermore, cooperating in any somewhat irreversible arrangement – as that would be the case from sharing irrigation infrastructures with a group of neighboring farmers – increases the risk of conflict, disputes and financial losses. As Marshall (2004) notes, trust and cooperation are pivotal factors in providing collective goods. Thus, in answering how much cooperation one should expect from one another it is essential to study whether trust and mutual assurance are established in a group (ibid.).

Irrigation districts in developed countries have been given a strong support from government agencies, involving financial support, technical advice and law enforcement. In developing countries none of these can be summoned easily to establish irrigation districts. As committing to formal collective arrangements entails personal and financial costs, in contexts of poor and enfant institutions, the mere reference of a policy goal in a water law is a poor bait for dubious farmers to enter into arrangements. Farmers pondering whether to invest in participating and formalizing in irrigation districts must be convinced that the benefits will be greater than the ones obtained by individual action.

Considering a simple agricultural household model that includes participation in collective action initiatives and technology adoption (Singh, 1986; Fernandez-

Cornejo *et al.*, 2005; Willy and Holm-Müller, 2013), a household decision to participate in off-farm activities that have an impact on farm household income will depend on the relation between the wage rate and the marginal product of farm labor. Whenever the marginal benefit of adoption is below the marginal cost of adoption, it will not be optimal the adoption of technology. This theoretical foundation can be used to examine participation in collective action and the decision to participate in collective irrigation systems. The following section describes the empirical models and estimation strategies.

5.3   Methods

5.3.1   *Empirical framework*

Our empirical approach is based on Willy and Holm-Müller (2013), who analyzed collective action initiatives and soil conservation effort in an environmental program. Following their approach, we develop a two-stage econometric model to analyze the effect of social capital and collective action in irrigation organization. This two-stage approach allows us to account for self-selection problems as participating in collective action initiatives at the community level might depend, among other factors, on the environmental hazards affecting the community and the household characteristics, including the level of social capital. Therefore, the fact that some households might be self selected into participation needs to be taken into account.

In the first stage, a binary probit model is used to regress the frequency of collective action on the level of social capital, the exposure to water-related natural hazards and household characteristics. The general specification of a binary outcome model is:

$$y_{1i}^* = \beta_1' x'_{1i} + \varepsilon_1 \tag{1}$$

Where i is the observation, y_{1i}^* a latent variable, x'_{1i} the set of explanatory variables, β_1 a vector of coefficients to be estimated, and ε_1 a random error term. Although y_{1i}^* is unobserved, we observe the variable y_{1i} if the latent variable y_{1i}^* exceeds a certain threshold. The dependent variable $y_{1i} = 1$ if a farmer states that the frequency with which the community has met to pursue development projects that favor the community exceeds two times a year and $y_{1i} = 0$ otherwise.

$$y_{1i} = \begin{cases} 1 \ if \ y_{1i}^* > 0 \\ 0 \ if \ y_{1i}^* \le 0 \end{cases} \tag{2}$$

From the first stage, the inverse Mills ratio (Heckman, 1979) is generated and enters the second model as an explanatory variable. In the second stage, we used a binary logit model to estimate the effect of collective action and attributes of the irrigation system and users on the probability of sharing the irrigation system:

$$y_{2i}^* = \beta_2' x'_{2i} + \hat{y}_{1i}^* \alpha + \varepsilon_{2;} \ \varepsilon_1 \sim NID(0, \sigma^2) \tag{3}$$

and

$$y_{2i} = \begin{cases} 1 \ if \ y_{2i}^* > 0 \\ 0 \ if \ y_{2i}^* \leq 0 \end{cases} (4)$$

where $y_{2i} = 1$ if a farmer shares the irrigation system with other people and 0 otherwise. Variable y_{2i}^* can be interpreted as the propensity to participate in irrigation organizations. x'_{2i} is a vector of explanatory variables conditioning the decision to participate in a collective irrigation system, $\hat{y}_{1i}^*$ are the inverse Mills ratio values obtained from the binary probit model in the previous step and ε_2 is a random error term.

The parameters in both models were obtained by maximum likelihood estimation in Stata 12.0.

5.3.2 *Survey instrument and data collection*

Primary data for this study has been collected through a household survey administered in July 2010 and March 2011, on a sample of 121 households. Survey design was based on the 2005 Nicaragua Living Standards Measurement Study Survey (LSMS), on the World Bank Social Capital Accounting Tool (SOCAT) and on a comprehensive literature review (Krishna and Uphoff 1999; Meinzen-Dick *et al.* 2002, Grotaert and Narayan 2004; Krishna 2004). Sample selection was based on the information provided by key informants, including community leaders, representatives from credit and savings cooperatives and civil organizations, and included all irrigators located along the sub-basin.

The survey included 65 questions and was divided into three parts. The first part gathers general household information. The second part focuses on agricultural production features and includes specific questions related to irrigated production, irrigation system and organization, land tenure system, commercialization and the major problems affecting production. The third part is devoted to social capital, distinguishing between structural and cognitive social capital[8].

Structural social capital includes variables related to social participation and social networks. Cognitive social capital refers to social support and trustworthiness. Regarding social participation variables, a factor analysis was carried out to generate an index on this component. For this purpose, specific questions on group membership, leadership, intensity of involvement in groups at household level and how the decisions are taken in the group were included in the survey. A factor analysis with orthogonal rotation was carried out on these variables and sampling adequacy was tested using the Kaiser-Meyer-Oklin (KMO) statistics. A predicted factor on group participation for each individual was obtained from this analysis.

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[8]The survey implemented is included in Appendix 2.

Social networks and cognitive social capital indicators were considered separately because the uniqueness level was above 0.6 and, then the variables are not well explained by the factors. With respect to networks, the respondents were asked how people would act when a pest infests all crops in the community. The responses could vary from the individual action to a community-level response to the problem. Cognitive social capital includes variables related to social support and trust at the community level. Thus, social support is considered in terms of monetary support in case of a large and unexpected economic loss affecting the household. In addition, we measured trust in people in monetary terms, i.e. trust to lend to or borrow money from people from the same community.

5.3.3 Description of variables

Summary statistics of the variables used in the estimation models are reported in Table 5.1. The dependent variable in the first model is frequency of collective action at community level (CAFREQ). This dichotomy variable measures whether the community has come together during the last year to apply for community development projects. In the study area, there are a number of development NGOS working in agriculture and water and sanitation provision, which gives interested communities the opportunity to participate in these type of projects. In addition, the government of Nicaragua has also fostered agricultural projects through the Institute of Rural Development. It is worth noting that 62 out of the 121 households included in the sample had participated in some kind of agricultural development project in the past 5 years.

The dependent variable in the second model is participation in collective irrigation systems (IRRCOM). Respondents were asked whether they shared any irrigation system with some other people. It should be noted that in all cases collective irrigation is informal, as irrigation districts have not been formally developed in the country.

The explanatory variables included in the first model are: perception of self-influence in the community, that is, the capacity a person thinks he/she has to make the community a better place for living (PERINF), the valuation of community members contribution with money and/or time to community development projects (CONTCOM), the type of transport used for taking the production from the farm to the sale point (TRANSP), the number of people in the household (NHHOLD), the number of years the household head has lived in the community (YCOM), the ratio between cultivated land and household members (SUPCAP), the social participation factor from the factor analysis referred in the previous section (SPARFACTOR), the intensity of social networks refers to the number of networks that would provide assistance if a problem affects the whole community (e.g. a crop pest) (NETW), social support in case a household in the community losses the harvest producing (SOCSUP), whether people in the community trust their peers for

lending and/or borrowing money (TRUST) and whether a flood and/or drought affected the household agricultural production (PWAT).

Table 5.1 Summary statistics for the dependent and explanatory variables.

Variable	Description	Mean /proportion	Std. dev.	Expected sign
Dependent variables				
CAFREQ	Frequency of collective action (1=at least twice a year)	0.50		
IRRCOM	Collective irrigation (1=yes)	0.57		
Explanatory variables				
Binary probit				
PERINF	Perception of self-influence in the community (1=low – 3=high)	1.84	0.72	+
CONTCOM	Contribution with money/time to community projects (1=low – 2=high)	1.62	0.79	+
TRANSP	Transport used for commercialization (1=animal – 4=truck)	1.62	1.84	+/-
NHHOLD	Number household members	4.86	2.02	+/-
YCOM	Years living in the community	44.68	19.74	+
SUPCAP	Land per household member (ha/per)	3.11	6.32	+/-
SPARFACTOR	Social participation factor	0	1	+
NETW	Intensity of social networks (0=any network – 5 networks)	1.03	0.89	+
SOCSUP	Type of social support (1=nobody, 2=community, 3=leaders; 4= government & NGOs)	2.51	1.17	+
TRUST	Trust in the community members? (1=trust)	0.50		+
PWAT	Affected by flood/drought during last year (1=yes)	0.82		+
Explanatory variables				
Binary logit				
IRRLAND	Total irrigated land by household (ha)	2.34	2.60	+/-
EDUHH	Household head education level (1=no schooling – 8=university degree)	3.12	1.75	+
IRRTEC	Irrigation technology (1=canal – 4= artesian well)	1.91	0.77	-
WATSOUR	Water source for irrigation (1=river, 0=other)	0.65		+/-
LANDTEN	Land owned with title (1=yes)	0.80		+
IMR	Inverse Mills ratio	0.89	0.59	+

Independent variables in the second model include: the total land cultivated under irrigation by a household (IRRLAND), the maximum level of education attained by the household head (EDUHH), the type of irrigation technology, distinguishing among canal, pump from the river, hand-made wells and artisan wells (IRRTEC),

the water source for irrigation (WATSOUR) and land tenure (LANDTEN). The inverse Mills ratio (IMR) generated from the first model on frequency of collective action identifies the sample selection bias. That is, if the frequency of collective action at community level affects the probability of participating in collective irrigation.

5.4 Study area

The current study was conducted in the upper Rio Viejo sub-basin located in the Central-North region of Nicaragua (see Figure 5.1). The upper Rio Viejo sub-basin includes six major municipalities, covering 360 km². Our study focuses in two of them where irrigated production is mostly located. The region is located along the Central America drought corridor. Thus, whereas in the Atlantic coast annual rainfall averages 2500 mm, in this region rainfall levels are usually under 1200 mm annually with marked seasonal variability (INETER, 2010).

Irrigation takes place during the dry season and, in most cases, covers the months from November to April. However, the length of the irrigation season is highly variable depending on the hydrological year and on whether phenomena such as *El Niño* or *La Niña* occur. Overall, in Nicaragua there are three cropping seasons. However, usually two of them (named "apante" and "postrera" in Spanish) need irrigation, in particular, in the dryer areas of the country.
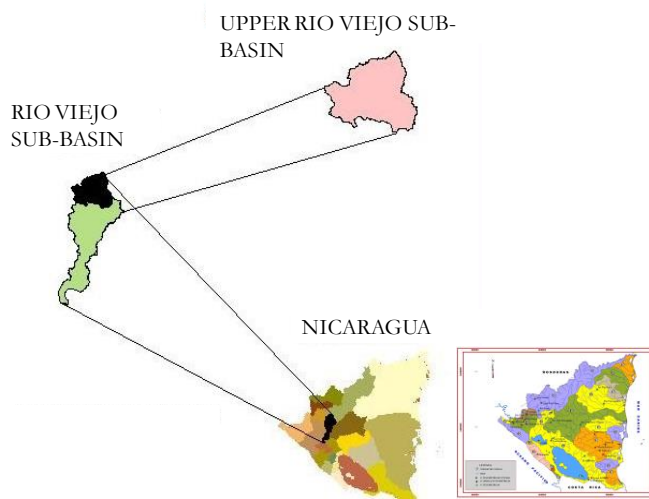
Figure 5.1 Map of the study area. Source: Own elaboration based on TERRENA program and INETER (2013b).

5.5   Results

5.5.1   *Collective action at community level*

Results indicate that 50% of the interviewees have got together to pursue community development projects at least twice during the last year. Frequency of participation in community meetings might be related to the success of previous collective action. Table 5.2tabulates the number of responses regarding frequency of collective action by success of these initiatives. There is a positive and statistically significant relation between frequency and success of collective action, suggesting that outcomes from past experiences might be a key determinant of future collective action attempts.

Table 5.2 Relation between success and frequency of collective action (N=121).

Success of collective action	Frequency of collective action	
	> 2 times/year	<2 times/year
Yes	47	3
No	13	58

Pearson chi^2=67.238, p=0.000

The frequency of collective action is also related to the valuation of participation in the community (Pearson chi^2=12.229, P=0.016). Thus, valuation of participation increases as frequency does and it is higher in those cases in which respondents value collective action as successful (Pearson chi^2=14.617, P=0.006), as shown in Table 5.3.

Table 5.3 Relation between frequency and success of collective action and valuation of participation in the community.

Frequency of collective action	Valuation of participation in community (n responses)				
	Very low	Low	Medium	High	Very high
> 2 times/year	1	9	22	22	5
<2 times/year	5	20	22	14	0
Success of collective action					
Yes	0	7	19	20	4
No	7	22	25	16	1

5.5.2   *Participation in collective irrigation*

A total of 69 households, out of 121 included in the sample, participate in a collective irrigation system. Considering the composition of irrigation groups, 30% of users indicate that members in the group are from the same family, as reported in Table 5.4. This result highlights the relevance of family-ties in the development of collective irrigation institutions in Nicaragua.

Table 5.4 Composition characteristics of irrigation groups, number of households.

Members in the group are from the same (n responses):				
	Family	Community	Associate	Friend
Family	21			
Community	7	5		
Associate	2	1	2	
Friend	6	8	3	12
Total	36	14	5	12

We also look at the relation between sharing an irrigation system and inclination to cooperate. In line with Krishna (2004), this is tested by asking which alternative he/she would prefer between owning 7 ha individually or sharing 18 ha with a friend from the same community, being the 7 ha alternative similar to the average land plot size in the area of study. The results, presented in Table 5.5, show that 80% of the sample would choose the first alternative and reject having access to more land under a shared production system. Nevertheless, considering those who expressed preference for the alternative "owning 18 ha jointly", most respondents share an irrigation system. This suggests that preferring cooperative solutions is more likely when individuals have had previous collective experiences.

Table 5.5 Relation between sharing an irrigation system and inclination to cooperate.

Shares an irrigation system	Preference to own (n responses)		
	7 ha individually	18 ha jointly	Total
Yes	50	19	69
No	46	6	52
Total	96	25	121

Pearson chi^2 = 4.630, p = 0.031

5.5.3 Regression results

Results from the two-stage econometric model are presented in Table 5.6 and Table 5.7. Table 5.6 reports regression results on the determinants of frequency of collective action. Table 5.7 shows the results for the second-stage model explaining participation on collective irrigation. Pregibon's link test for model specification and Hosmer-Lemeshow statistics indicate that both models are correctly specified and the models fit moderately well the data (p>0.1).

Social capital variables, except for the social participation factor, are significant factors in explaining the frequency of collective action (p<0.05). As expected, the coefficients are positive, indicating that the higher the intensity of social networks, type of social support and trust, the higher the frequency of collective action in the community. As suggested by Krishna (2004), responses related to group membership, trust, solidarity and reciprocity are highly correlated. In this respect, a Wald test indicates that we can reject the null hypothesis that the effects of these variables on the frequency of collective action are simultaneously equal to zero

($X^2_{df=3}$= 9.87, p= 0.020). The average marginal effects in Table 5.6 indicate that a unit increase in the number of available social networks to the household increases the frequency of collective action by 10.4%. Regarding the type of social support, a unitary increase of this variable increases the frequency of collective action by 5.8%, indicating that households connected to more powerful structures are more willing to engage in collective action at community level. The effect of trust is noteworthy. Thus, trust in the community increases the frequency of collective action by 15.7%.

Valuation of community members' contribution to community development projects is positive and statistically significant. A higher valuation of the contribution with time and/or money relates to higher frequency of collective action. However, the variable indicating perception of self-influence in the community is not statistically significant. Both factors might complement each other as indicated by their joint influence on the frequency of collective action (Wald statistics, $X^2_{df=2}$= 6.72, p= 0.035).

The results show that the variables *number of household members* and *land per household member* are significant and negatively related to the frequency of collective action. Both a larger number of household members and hectares per member decrease the frequency of collective action. This result might point out to an inverse U-shaped relation between collective action and the level of household assets. Thus, one would expect little capacity or willingness to participate in households with little per capita assets, because there is little to be gained from such social investment to the extent that there would be little financial leverage in the households' economy (Bowles, 1998). But one would also expect that households' owning large assets would gain little from cooperation, because individualistic strategies may afford more secure payoffs than complex collective endeavors (Sandler 1992). The average marginal effect is larger for the number of household members. Thus, a unit increase in the household size reduces the frequency of collective action by 8.5%.

The fact that a household has been affected by a flood and/or a drought during the last year is significantly related to the frequency of collective action. It is worth noting that the estimated average marginal effect of this variable is higher in comparison with the effect of the other variables included in the regression model. Households affected by one of these water-related events are 25.0 percentage points more likely to participate in collective action initiatives at community level. Thus, emergence of collective action might be catalyzed by external shocks which put the system under stress, requiring the search of collective solutions that enable users to deal with the disturbances. White and Runge (1995) conclude that emergence of collective action will take place in those settings in which there is a "critical mass" with practical knowledge of the potential gains from their action.

Table 5.6 Regression results for individual data explaining frequency of collective action.

Variable	Coeff.	Std. error	Average Marginal effects
Constant	-1.249*	0.750	
PERINF	0.252	0.193	0.073
CONTCOM	0.345**	0.176	0.100
TRANSP	-0.111	0.077	-0.032
NHHOLD	-0.292***	0.077	-0.085
YCOM	0.003	0.007	0.001
SUPCAP	-0.058*	0.033	-0.017
SPARFACTOR	0.077	0.129	0.022
NETW	0.361**	0.169	0.104
SOCSUP	0.201*	0.120	0.058
TRUST	0.543*	0.287	0.157
PWAT	0.864**	0.375	0.250
N observations	120		
Pseudo R²	0.26		
LR x^2(11 d.f.)	43.20***		
Log likelihood	-61.580		
% of correct predictions	74.17		

*** p<0.01, ** p<0.05, * p<0.1

Table 5.7 presents regression results for the second model explaining participation in collective irrigation systems. We can observe that the variable *irrigation technology* is negative and significantly related to collective irrigation. As expected, canal irrigation takes places mostly collectively, suggesting that maintenance and operation costs need to be shared among the group in order to obtain net irrigation benefits at household level. However, the fact that the variable *water source for irrigation* is negatively related to collective irrigation indicates that farms located on the riverside are less likely to engage in collective systems. This might suggest that the cost of cooperation, including both physical and social capital investments, surpass the cost of individual action. Thus, we find that farms located at the river banks pump water directly from the river, using individual equipments.

Surprisingly, the effect of land tenure on collective irrigation is negative and statistically significant. A closer look at the data reveals that 78% of the households which share an irrigation system have a land title. However, the fact that 90% of those households with individual irrigation systems have a land title also suggests that secure land tenure is not a sufficient condition for willing to participate in collective irrigation. In fact, it may be a deterrent in the sense that it may compromise the value of the title to the extent that the land could be landlocked within a structure of canals or some other fixed binding.

The Inverse Mills ratio is negative and statistically significant, indicating the presence of a negative selectivity bias in the model. This implies that an individual with average sample characteristics who self selects into participation in collective action

is less likely to share an irrigation system, compared to an individual with average set of characteristics drawn at random from the population. Frequency of collective action at community level does not enhance participation in collective irrigation. Family ties play an important role in the development of collective irrigation institutions, as shown in Table 5.4. Alesina and Giuliano (2009) establish an inverse relationship between family ties and civic engagement. Thus, the closer the family ties are, the more a person relies on the family as a provider of insurance and resources, diminishing the political and civic engagement.

Table 5.7 Regression results for individual data explaining participation in collective irrigation.

Variable	Coeff.	Std. error	Average Marginal effects
Constant	8.196***	1.900	
IRRLAND	-0.021	0.084	-0.004
EDUHH	-0.032	0.143	-0.006
IRRTEC	-2.087***	0.543	-0.378
WATSOUR	-2.207***	0.810	-0.400
LANDTEN	-1.315*	0.740	-0.238
IMR	-0.745*	0.386	-0.135
N observations	109		
Pseudo R²	0.19		
LR x^2(6 d.f.)	27.39***		
Log likelihood	-58.48		
% of correct predictions	77.06		

*** p<0.01, ** p<0.05, * p<0.1

5.6 Conclusions

In this study, we investigate the effect of collective action at community level on the participation in collective irrigation institutions in the North Central Region of Nicaragua. The research attempts to provide clues about what makes communities and individuals more willing to participate in irrigation districts, which the Nicaraguan Water Law aims at creating in the rural areas. For this purpose, we used a two-stage econometric approach to estimate the frequency of collective action at community level and participation in collective irrigation systems.

Our empirical study shows that 50% of the sample has engaged in collective action at community level. Regression results indicate that the intensity of social networks, the type of agents willing to provide social support and the level of trust in the community are all significant factors explaining the frequency with which the community has come together to pursue development projects. The fact that a household has been affected by a drought and/or a flood increases the likelihood of collective action at community level. This finding, consistent with the empirical literature on the emergence of collective action, suggests that exogenous shocks are key determinants in the development of collective action at community level.

Participation in community meetings was found negatively related to participating in collective irrigation systems. Although unexpected, we find this result particularly interesting given that most collective irrigation relies on family ties. Thus, 54% of those participating in collective irrigation systems indicate that the infrastructure is shared with people from the same family. In this respect, establishing formal irrigation institutions in Nicaragua might benefit from taking into account the importance of strong family ties in the social construct and the extent to which this might influence water institutions. Critical social capital variables might be defined within the family nucleus and difficult to go beyond these ties.

The fact that collective irrigation is more likely when there is a canal system highlights the importance of the origin of the collective action and the preference for individual action given the current structure of incentives. Canal irrigation was promoted during the Somoza dictatorship (1934-1979) and, in some cases, maintained by the Sandinista land reform in the 80s as a result of the promotion of agricultural cooperatives. However, farmers located nearby the riverside are less likely to engage in collective systems as individual action is enough to gain access to the resource. This suggests that farmers located on river banks will tend to cooperate less, and in times of reduced flows coordination and sharing among them will be more difficult than if they were located at more distance from the source and needed to rely on common infrastructure.

6 Agents' behavior and collective governance of irrigation systems: Evidence from field experiments in Nicaragua

Abstract

The objective of this chapter is to analyze agents' decisions about common pool resource appropriation and public good provision in a dynamic setting. We carried out a total of 45 games in Nicaragua, including 88 villagers in rural communities and 92 undergraduate students. Individuals must decide how much common pool resource to appropriate and how much public good they provide afterwards. In 9 out of 22 villagers' groups, we introduced an information disclosure treatment that informed the groups about peers' appropriation of the common pool resource. The results show that students and villagers behave differently, with villagers allocating more units of effort to common pool resource (CPR) appropriation than students. This affects CPR availability and determines the efficiency of the game. We also found that the level of effort allocated to appropriation, but not of public good provision, is sensitive to the physical position along the system. Results also suggest that information disclosure decreases the level of public good provision, affecting the distribution of payoffs at group level. Finally, individuals' pro-social traits and group heterogeneity in terms of sex composition are significant variables in explaining efficiency outcomes and effort decisions along the game.

Publications

- Novo, Paula, and Alberto Garrido. (*under review*). Appropriating and preserving the commons: Evidence from field experiments in Nicaragua.
- Novo, Paula, and Alberto Garrido. 2013. Dynamics in the governance of collective irrigation systems: Evidence from field experiments in Nicaragua. *20th Annual Conference of the European Association of Environmental and Resource Economists*. 26-29 June 2013, Toulouse, France.

6.1   Introduction

Low investment in operation and maintenance activities is often considered as one of the main causes of poor irrigation performance. While initial irrigation investments are in many cases supported by development and government projects, infrastructure operation and maintenance are often left in the hand of farmers. In this respect, considerable evidence suggests that much of the long-term success of irrigation systems depends on how users solve two simultaneous collective action problems (Baland and Platteau, 1996; de Janvry *et al.*, 1998; Janssen *et al.*, 2011, 2012). On the one hand, the organization must guarantee a well-functioning infrastructure to distribute and utilize water resources, which has many properties of a public good. On the other hand, the relative positions along the system generate asymmetric access to the resource. Both collective action problems add additional complexity to the traditional social dilemma between the individuals' appropriation effort that maximizes individual payoffs, and the social interest that drives to resource conservation.

Willingness to cooperate in social dilemmas has been tested through different experimental methods (Cardenas and Carpenter, 2008). A common finding is that the average player tends to deviate from the pure selfish maximizer of individual payoffs, even when there are incentives to free-ride (Cardenas, 2011). This fact suggests that individuals' decisions may be mediated by other factors in addition to pecuniary payoffs (Ostrom, 2000; Cardenas, 2009). Meinzen-Dick *et al.* (2002) find that, in addition to size of the command area and distance to market, leadership and social capital factors, such as the presence of influential persons and number of temples, play a major role in explaining success of collective action in canal irrigation systems in India. Araral (2009) presents similar results for the case of irrigation associations in the Philippines. Empirical evidence indicates that in many settings the adoption of pro-social norms allows users to overcome social dilemmas in common pool resources (Narloch *et al.*, 2012).

The effect of individual and social preferences has long been discussed in the common pool resources and public goods literature (Andreoni, 1988; Ostrom, 1990; Walker *et al.*, 1990; Ledyard, 1995). Thus, Camerer and Fehr (2006) also show that, in contrast with the canonical model of economic behavior, most individuals care about the outcomes and the behavior of other individuals, prefer equitable outcomes and tend to mimic cooperative behavior. Fehr and Fischbacher (2003) argue that strong reciprocity, in the form of altruistic rewarding and altruistic punishment, is a relevant incentive for cooperation among individuals. Other economic experiments also support the view that conditional cooperation and costly punishment of free riders are key factors for sustained cooperation (Boyd *et al.*, 2010; Gintis and Fehr, 2012).

Experimental research has also addressed the question of how groups solve simultaneous collective action problems when there is asymmetry in access to the

70

common pool resource (CPR). For this purpose, Janssen *et al.* (2011, 2012) designed an irrigation game in which participants firstly decide, in sequential turns, how much to invest in a public fund that generates the CPR available for the group. Subsequently, players decide sequentially how much to appropriate from the CPR. The authors find that the share upstream participants take from the resource affects the cooperative behavior of downstream players, creating a synergic process between efficiency and equity. In line with previous findings, participants with a higher trust in other community members display a more cooperative behavior in the game.

In this paper we build on the experimental design of Janssen *et al.* (2011, 2012), Osés-Eraso *et al.* (2008) and Osés-Eraso and Viladrich-Grau (2007, 2011) to analyze appropriation and public good provision decisions in a common pool resource context. Compared to the setup of Janssen *et al.* (2011, 2012), our game is dynamic and the appropriation stage is played prior to the public good provision stage, as this would be the case in those irrigation systems in which the infrastructure is initially provided and users are responsible of subsequent operation and maintenance. By introducing dynamics, we can account for the effect of endogenous CPR scarcity on appropriation and public good provision decisions. Previous studies suggest that participants react to the actual level of resource scarcity, but this response is not enough to restraint appropriation (Osés-Eraso *et al.*, 2008). As in Janssen *et al.* (2011, 2012), in our game players have sequential access to the resource. In addition, in some of our groups, we implement an information treatment with the purpose of testing whether adding individual appropriation data changes individual's decisions in the following rounds. Information disclosure might act as a reputational indicator and provide information on the possible appropriation inequalities among group members.

Therefore, the objective of this study is to analyze CPR appropriation and public good provision decisions by a group of subjects, consisting of undergraduate students and villagers in Nicaragua, testing the effect of pro-social preferences and information disclosure in appropriation decisions. We achieve this objective by combining a field experiment and a survey on pro-social preferences.

The chapter is organized as follows. Section 6.2 presents the irrigation game and the game benchmarks. Section 6.3 describes the game parameters, experimental context and procedure. Section 6.4 presents the survey on social preferences. Section 6.5 summarizes the major results and section 6.6 lays down the conclusions of the paper.

6.2   The irrigation game

6.2.1   *Game description*

A group of n players share a CPR, framed as a common pool water resource, of F_0 points. Before the first round, participants are randomly assigned to a position (i.e.

P₁, P₂, ..., Pₙ) with sequential access to the CPR. This position remains fixed all over the game. In each round participants face two stages: the appropriation stage and the public good provision stage. Each participant receives and initial endowment of e points. After the first round, the individual endowment is endogenously determined (e_{it}) as described below in Eq.6. In the appropriation stage, each participant, in sequential turns from upstream (P₁) to downstream (Pₙ), makes a decision on how much effort x_{it} (measured in points) allocates to appropriate units from the CPR. Effort decisions are constrained by the player's endowment ($x_{it} \leq e_{it}$). Each point of effort used for CPR appropriation yields an individual marginal benefit of w points, but causes the CPR a marginal reduction of c points. Each point kept (not used for CPR appropriation) has a marginal value for the agent of a points. Let x_{it} be the effort of player i in round t, the appropriation payoff (z_{it}^A) the player obtains in that round will be:

$$z_{it}^A = wx_{it} + \alpha(e_{it} - x_{it}) \tag{1}$$

With $w > a$ in order to create an incentive for appropriation from the individual point of view.

After player i appropriation, the CPR available to the next player j in round t (F_{jt}) will be equal to the CPR available to player i (F_{it}) minus player i appropriation (cx_{it}):

$$F_{jt} = F_{it} - cx_{it} \ for F_{jt} > 0 \tag{2}$$

After the appropriation stage of round t, the remaining CPR (F_t^A) will be equal to the CPR that remained from the previous round ($F_{t-1}^R = F_{1t}$) less the total common pool resource appropriated by the group ($X_t = c(\sum_{i=1}^n x_{it})$). Total group appropriation, X_t, is provided to all agents before the public good provision stage of each round t. In the information treatment, both group and individual appropriation is provided to the group after round fourth:

$$F_t^A = F_{t-1}^R - c(\sum_{i=1}^n x_{it}) \qquad for \ F_t^A > 0 \tag{3}$$

The second stage is the public good provision stage. In each round t, players simultaneously decide how much to contribute from the appropriation payoff (z_{it}^A) to a public fund for operational and maintenance activities. Points contributed to this fund (y_{it}) result in a marginal reduction of β points of individual's appropriation payoffs but yield a marginal increase of m points in the CPR. After the public good provision decisions of round t, the remaining common resource (F_t^R) that subjects share for the next round is:

$$F_t^R = F_t^A + m(\sum_{i=1}^n y_{it}) \tag{4}$$

Under this two-stage asymmetric game, the earnings of each participant in round t result from the effort spent in appropriation (x_{it}) and public good contribution (y_{it}) decisions. The resulting payoff z_{it} for player i in round t is, therefore, defined as the appropriation payoff less the public good provision expenditure:

$$z_{it} = z_{it}^A - \beta y_{it} \tag{5}$$

Given the dynamic nature of the game, the endowment of subject i in round t is defined by the following expression:

$$\begin{cases} e_{it} = e & if \; t = 1, i = 1,2,\dots,n \\ \quad e_{it} = z_{i(t-1)} & if \; t > 1 \end{cases} \tag{6}$$

If the last round T is reached, the remaining CPR, F_T^R, is equally distributed among the n members of the group. Suppose a total number of T rounds are played, then the game payoff z_i obtained by player i is equal to the payoffs from the last round plus the share of the remaining CPR, if available:

$$\begin{cases} z_{iT} + \dfrac{F_T^R}{n} \; if \; F_T^R > 0, \; F_T^R = F_{T-1}^R - c(\sum_{i=1}^n x_{iT}) + m(\sum_{i=1}^n y_{iT}) \\ \qquad\qquad z_{iT} \, otherwise \end{cases} \tag{7}$$

Appropriation effort decisions can be taken as long as the CPR maintains a positive value. For the purpose of this experiment, decisions can be taken over a maximum of T rounds that would represent the number of turns on an irrigation campaign, but this information is not revealed to participants beforehand. *Early-extinction* of the game takes place when the CPR takes a negative or zero value in a period $t^*<T$ or public good contribution equals the appropriation payoff ($y_{it} = z_{it}^A$). In that case, the player would not have any endowment left for investing in the next round. From Eq.2, it can be deduced that the CPR will be exhausted if $x_{it} \geq F_{it}/c$.

6.2.2 Game benchmarks

In order to describe the canonical solutions to the social dilemma associated with CPRs, the game assumes that appropriation and non-contribution to the PG are more efficient from the individual perspective, while non-appropriation and contribution to the PG are more efficient from the collective perspective. Thus, we define three possible game outcomes: 1) the individual strategy, 2) the social strategy, and 3) the mixed strategy.

The individual strategy

A rational agent i would maximize the game payoffs obtained in the last round T and described in Eq.7. The individual marginal net benefit from appropriation is ($w - c/n$) while α is the individual marginal net benefit from not investing in appropriation. The individual marginal benefit from public good provision is m/n

and β the individual marginal cost. Given that individual marginal net benefit from appropriation is larger than the net benefit of not investing in appropriation, $(w - c/n) > \alpha$, and the net benefit from public good provision is lower than the marginal cost, $m/n < \beta$, then the net benefit from appropriation is larger than the net benefit from public good provision. That is, $(w - c/n) > \alpha > (m/n - \beta)$.

Via backward induction we find that, under the above conditions, if participants were rational self-interested individuals they would choose full-appropriation $(x_{iT}^* = e_{iT})$ till the resource is depleted and none would contribute to public good provision activities that increase the amount of CPR available $(y_{iT}^* = 0)$. Since the upstream player is expected to use all his endowment for CPR appropriation, downstream participants will not contribute to public good provision. Therefore, for player 1 there is no benefit to contribute when others will not. Thus, the Nash equilibrium for this game is that all players invest their initial endowment $(e_{it=1} = e)$ in CPR appropriation and nobody contributes to public good provision. Considering that the initial amount of CPR is defined as $F_o = nce$, if every player invests his whole initial endowment in appropriation, the CPR will be exhausted in the first round and the game payoffs for each player will be $z_i^{I*} = we$.

The social strategy

A social optimum solution involves the maximization of the aggregate game payoff in the final round *T*. As we assume that $(w - c) < \alpha$, that is, the aggregate marginal net benefit from appropriation, $(w - c)$, is lower than that associated to non appropriation in the first stage of the game, α, and the marginal cost from public good provision, β, is lower than the aggregate marginal net benefit, m, then $(w - c) < \alpha < (m - \beta)$. Therefore, the best social strategy, assuming fully cooperating individuals, is achieved when players do not appropriate, but invest all their initial endowment in public good provision activities, $x_{iT}^* = 0$ and $y_{iT}^* = e_{iT}$. If all players invest their initial endowment in public good provision, the game payoffs for each player will be $z_i^{S*} = F_0/n + me$. As $(c + m) > w$, $z_i^{S*} > z_i^{I*}$. This social optimum solution would be achieved if all players do not invest in appropriation or public good provision in rounds *T-1* and allocate all their endowment to public good provision in round *T*. In this way, participants can generate more CPR units and reach the maximum payoffs, which, could be invested in the next irrigation campaign.

The mixed strategy

In this strategy, we consider a player with an effort level in the first round between 0 and the initial endowment, $0 < x_{i1} < e$, and an effort level in subsequent rounds between 0 and the effort level that would lead to full appropriation and *early-depletion* of the CPR, $0 < x_{it} < F_{it}/c$. In this situation, as $m < c$, the share of the remaining

resource in the final round T will be lower than the share of the initial resource, as in the social strategy, that is $F_T/n < F_0/n$. In addition, payoffs from the round T will be lower compared to the individual strategy, as part of the appropriation payoffs are invested in public good provision. As the marginal cost of appropriation is larger than the marginal increase due to public good provision, the amount of CPR generated does not compensate the amount appropriated unless the subject contributes to the public good more than the effort allocated to appropriation ($y_{it} > x_{it}$), which would reduce individual appropriation payoffs. Therefore, aggregate game payoffs from the mixed strategy are lower than the individual and social strategies, $z^M < z^{I*} < z^{S*}$.

Compared to the previous strategies, in the mixed strategy, individual payoffs might differ among players depending on the appropriation and public good contribution behavior of group members.

6.3 Experimental context and procedure

Experiments were performed between July and August 2012 with undergraduate students and villagers in Nicaragua. The experiment was presented as an irrigation game. The typical experiment lasted about two hours with students and up to three hours with villagers. Each participant took part only in one experimental session. Participants knew who else was participating, but they were not allowed to communicate among each other during the experiment. All players were assigned a code at the beginning of the session in order to ensure anonymity for the game and the surveys. University students were recruited via word of mouth from the economics and agronomy degrees at the Universidad Nacional Autónoma de Nicaragua in the cities of Jinotega and Matagalpa (Central Region of Nicaragua). Villagers were recruited via word of mouth and flyers inviting participants 14 years and older to take part in the game. Only one person from the same household was allowed to participate in the same group. During the experimental sessions, assistance was offered to those participants who had difficulties with writing and/or arithmetic. In addition, subjects were told that the points earned in the last round would be exchanged for cash. On average, earnings per student amounted 2\$ and per villager 1\$. In the case of villagers, a show-up fee of 1\$ was given.

Both in the experiments with students and with villagers, participants were randomly assigned to the groups and positions. Groups were composed of $n=4$ players, each of whom received an initial endowment of $e=20$ points. The initial size of the CPR was $F_0=240$ points. At the appropriation stage, each point invested in appropriation yielded a marginal (individual) benefit of $w=2$, and decreased the CPR by $c=3$. Each unit not invested in appropriation produced a marginal benefit $\beta=1$. In the public good provision stage, each point invested in a fund for operational and maintenance activities produced an individual cost $\beta=1$ and increased the CPR by $m=1.5$. Taking into account these parameters, the game payoffs for the strategies defined earlier are:

Individual strategy: $z_i^{I*} = 40$ points; $z^{I*} = 160$ points

Social strategy: $z_i^{S*} = 90$ points; $z^{I*} = 360$ points

Mixed strategy: $z^M < 160$ points

After instructions[9] and a round of practice, participants played for a maximum of T=10 rounds. The game finished if the group reached 10 rounds, but participants did not know in advance the maximum number of rounds they would play. The remaining common water resource, equally distributed among the group players in the last round played, can take any value F_T within the closed interval [0, 360].

Experiments with undergraduate students included 92 participants (23 groups of 4 students), and were performed using pencil and paper. The average age of the students was 21 years (std. dev.=2.3), and 46% of them were female. Experiments in the field were conducted in seven different rural communities in the Department of Jinotega. A total of 88 subjects, 48 females and 40 males, participated in 22 groups. The average age of villagers was 34 years (std. dev.=13.3). In the field experiment, we implemented the information treatment. In 9 out of 22 groups, after the 4th round, individual CPR appropriation was made public before the second stage of the game, in which the participants had to decide how much to contribute to operational and maintenance activities of the public infrastructure. The number of groups by sex composition in each treatment is reported in Table 6.1.

Table 6.1 Number of groups by sex composition and treatment.

Group composition	N student groups (N players)	N villagers groups (N players)	
		T1 no information	T2 information*
4 males	5(20)	3 (12)	2(8)
4 females	8 (32)	5 (20)	2(8)
2 males & 2 females	4 (16)	2 (8)	2(8)
1 males & 3 females	2 (8)	1 (4)	2(8)
3 males &1 female	4 (16)	2 (8)	1(4)
Total	23 (92)	13 (52)	9 (36)

*In these groups, after round four, individual extraction levels were publicly shared among the group members.

Farming is the major source of income in the rural households in 81 out of 88 participants. In terms of the maximum level of education attained, 9% had no formal education, 3% are literate, 36% completed primary studies, 34% had secondary studies and 16% received technical or university training.

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[9] The written instructions are in Appendix 3. These were provided to the student's group. In the villagers' case, the game was explained with the support of a game board representing the CPR and the player's positions.

6.4   Survey design

At the end of the game an individual survey was completed to collect information on pro-social preferences and risk attitudes. Table 6.2 shows the questions covered in the survey[10]. There are certain differences between students and villagers, as we try to keep simpler the questions included in the villagers' survey.

Table 6.2 Survey contents on pro-social behavior and risk preferences.

Preferences involved	Students' questions		Villagers' questions
Inclination to cooperate	Voluntary Contribution Mechanism Willingness to share land		
Trust & reciprocity	Trust Game		Trust community
Altruism	Dictator Game		
Fairness	Ultimatum Game		
Risk	Accept/reject choices	lottery	Choose lottery

Willingness to cooperate is measured through two questions. The first question relates to the willingness to share 18 ha vs. owing 7 ha on their own. The second question takes the form of a Voluntary Contribution Mechanism. Participants are asked how much they would be willing to contribute, from a given endowment of 4$, to a public fund shared with other 3 players. Each dollar a person invests in the public fund generates 0.4$. At the end of the game, the public fund is equally distributed among the players.

For measuring trust and reciprocity, the survey included two questions. In the case of students, we included the trust game, in which the following situation is presented: the player receives 4$ and can send as much as he or she wants to a second player. The experimenter will triple the amount sent. The second player can then send back to the first as much as he or she wishes. In the question, the participant is asked to take the position of the first-mover and decide how much he/she would be willing to send to the second-mover. In the villagers' survey, based on the World Bank Social Capital Accounting Tool (SOCAT), we included the six statements related to trust and the community. Using a likert scale (1-4), participants were requested to define the extent to what they agree or disagree with the statement (1=strongly agree, 2= agree, 3=disagree, 4= strongly disagree).

Altruism is measured through the dictator game. In this game, the respondent has to state how much, from a received 4$ endowment, he/she would be willing to send to a second anonymous person.

Fairness is measured through a question that simulates the ultimatum game. The respondent is asked to imagine a situation in which he/she and another person have to distribute 4$ between the two. The other person is the first player and makes the

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[10] Students and villagers' surveys are included in Appendix 4.

offer on how to distribute the money, which the respondent can reject or accept. In case the offer is rejected, both players receive nothing. The respondent has to decided whether he would be willing to accept 1$ while the "proposer" keeps 3$. If he rejects this offer, he is asked whether he would accept 1.6$. If this offer is rejected then he is asked how much he would be willing to accept to close the deal.

In addition to pro-sociality, preferences over risk might be relevant in shaping inter-temporal decisions (Cardenas, 2011). Risk aversion in the students' survey is measured with lotteries developed by Holt and Laury (2002). Participants are presented with two columns of pair-wise lottery choices and they must decide which one to accept and reject. In the case of villagers, we measure risk aversion based on Binswanger (1980). In the survey, villagers are presented with lotteries that vary in risk and expected return and have to choose which one they would prefer to play. As reflected in Cardenas and Carpenter (2008), despite both studies' different approaches, Binswanger's estimation fits within the bounds estimated by Holt and Laury (2002).

6.5   Results

This section reports individual analyses of effort devoted to appropriation, and public good provision decisions along the game. The main results are structured in five observations. It is worth noting that, despite the individual incentives to allocate all the endowment as effort for CPR appropriation, instead most groups in both student and villagers' games reached round 10 (see Figure 6.1).
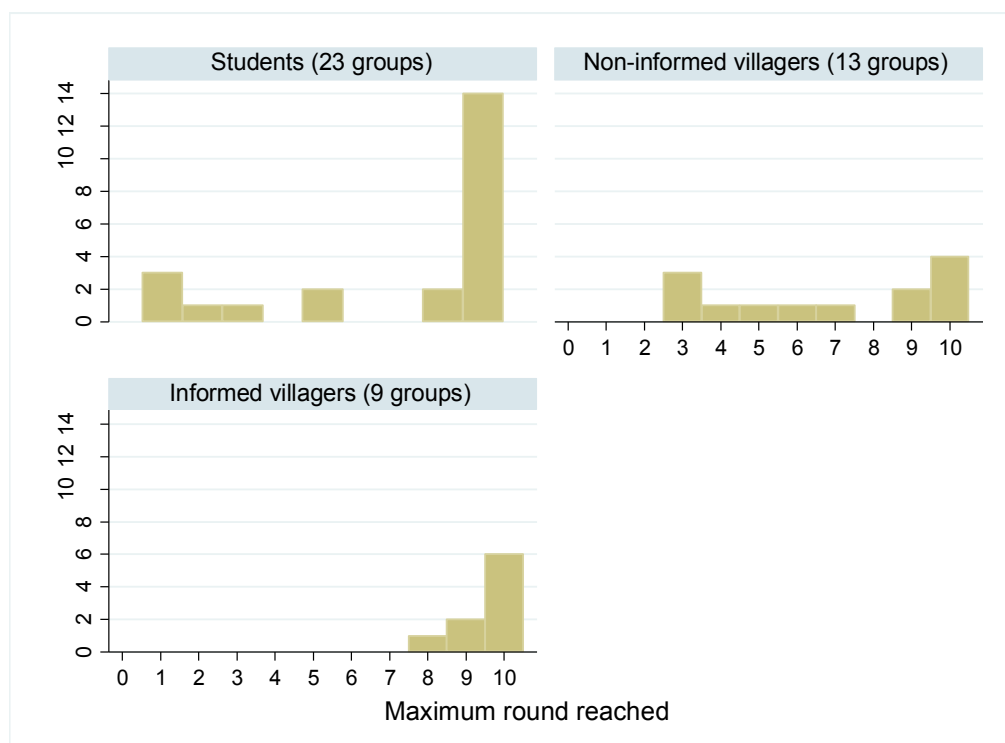
Figure 6.1 Group distribution by maximum round reached in the game.

6.5.1   Effort, appropriation and contribution decisions

Observation 1. *Disclosure of players' decisions affects the game strategy. Without information disclosure the CPR could not be depleted even if all subjects use all his/her endowment for appropriation. With information disclosure the CPR could be exhausted.*

Figure 6.2shows the median of appropriation and effort shares for students and villagers in each round. Informed and non-informed villagers are lined separately after round 4, when the information is disclosed in the informed villagers' game. We define the appropriation share (AS_{it}) as the ratio between appropriation and CPR available at Stage 1 of each round (f_{it}). It should be noted that appropriation is equal to the effort level (x_{it}) multiplied by the marginal reduction $c=3$ that each unit of effort exerts over the CPR. The effort share (ES_{it}) is defined as the ratio between effort (x_{it}) and endowment (e_{it}).

$$AS_{it} = \frac{x_{it} \times c}{f_{it}} \tag{8}$$

$$ES_{it} = \frac{x_{it}}{e_{it}} \tag{9}$$

When the CPR available at Stage 1 of the game is higher than three times the individual's endowment, $f_{it} > e_{it}$, the resource cannot be depleted even if the subject invests all her endowment in appropriating the CPR (i.e. $x_{it}=e_{it}$). In this case, the appropriation share is lower than the effort share. The results shown in Figure 6.2indicate that both students and villagers follow a strategy in which the CPR cannot be exhausted by a player even under full-appropriation, as the appropriation share is below the effort share. However, once the information about individuals' appropriation is disclosed in rounds subsequent to the fourth in nine out of the 22 villagers' groups, the difference between the effort and appropriation share decreases and, in some rounds, the appropriation share surpasses the effort share for informed villagers. This indicates that groups that receive information play a strategy in which the CPR could be exhausted.

It is worth noting that, when considering the complete game, differences in the distribution of both appropriation and effort shares between students and non-informed villagers are statistically significant (*AS*: z=-4.281, p=0.000; *ES*: z= -3.380, p=0.000). Non-informed villagers rank higher than students both in terms of appropriation and effort shares. These results might be explained by differences in the effort and endowment levels of students and non-informed villagers. Non-informed villagers rank higher than students in effort (z=-1.921, p=0.054), but students rank higher in endowment (z=2.447, p=0.014). Therefore, both effort and appropriation shares are smaller in the students' case.

With respect to the differences between informed and non-informed villagers, we cannot reject the null hypothesis of equal variances in the distribution of median effort and appropriation shares and, therefore, we cannot apply the Mann-Whitney

U test (Levene's test: *AS*: W=256.289, p<0.01; *ES*: W=172.464, p<0.01). Nevertheless, Figure 6.2 shows that both median effort and appropriation shares of non-informed villagers are higher than those of informed villagers. We find statistically significant differences in the distribution of the endowment, in which informed villagers rank higher than non-informed villagers (z= -5.622, p<0.01). As differences in effort distribution are not significant between both treatment groups of villagers, the larger the endowment, the lower the effort share for a given level of effort. Thus, the difference in endowment might explain that the median effort share of non-informed villagers is higher than that of informed villagers, as shown in Figure 6.2.
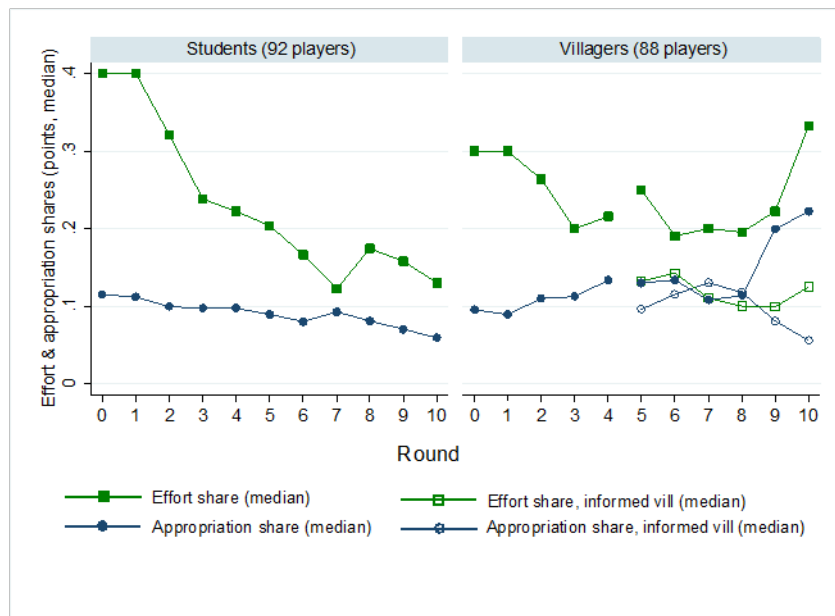
Figure 6.2 Appropriation and effort shares in students and villagers' games, median points per round.

Observation 2. *There is a positive correlation between appropriation and contribution to public good provision.*

Figure 6.3 plots average contribution and average appropriation per round and treatment group. As it can be appreciated, there is a decreasing trend both in appropriation and contribution to public good provision. In addition, Spearman correlation test shows that there is a statistically significant relation between appropriation and contribution decisions (students: $\rho=0.65$, p<0.01; non-informed villagers: $\rho=0.54$, p<0.01; informed villagers: $\rho= 0.49$, p<0.01), implying to some extent that contribution to the public good responds to the level of appropriation effort.

Contribution to public good provision is, as represented in Figure 6.3, below the appropriation level, which also explains the decreasing trend in CPR available shown in observation 1. It is worth noting that we do not find significant differences in the

distribution of contribution decisions of students and non-informed villagers (Mann-Whitney-U test: z=-0.951, p=0.342). But we do find significant differences between informed and non-informed villagers, with non-informed villagers ranking higher in contribution levels (Mann-Whitney-U test: z=3.919, p=0.0001). This result is consistent with the differences in the distribution of endowment between informed and non-informed villagers, as described earlier.
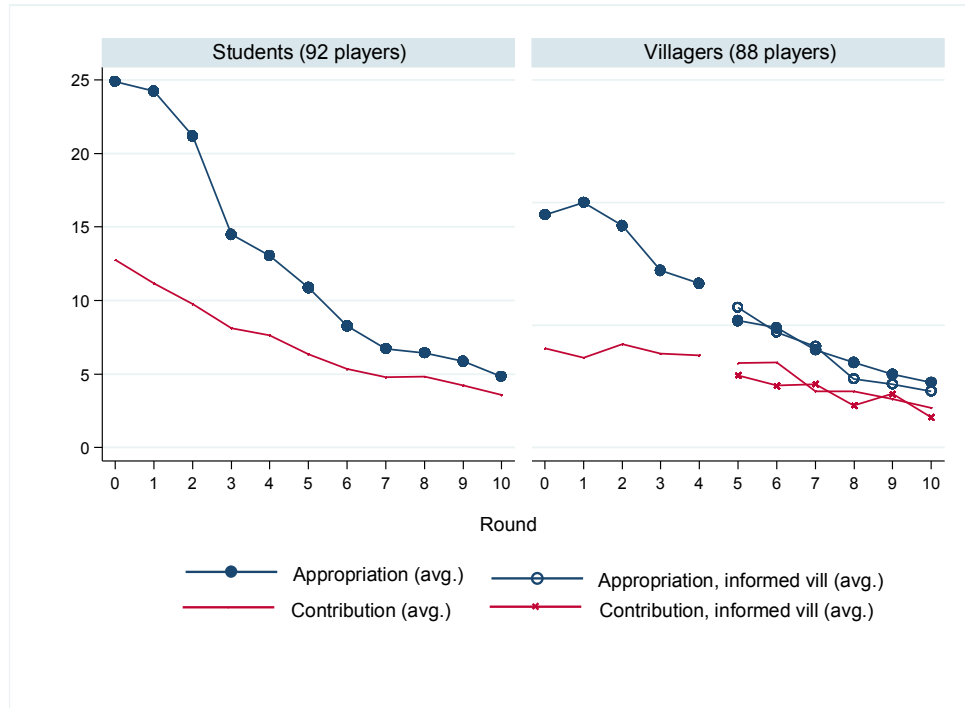
Figure 6.3 Average contribution and appropriation, average points per round.

Observation 3. *Appropriation effort increases with the position for villagers and decreases in the students' case. The ratio between player's appropriation effort and endowment is insensitive to the position.*

Considering the effect of player's position, we observe that there is a significant difference in the distribution of effort among positions. Average effort results are presented in Figure 6.4. While in the students treatment group effort increases for upstream participants in positions 3 and 4 (Mann-Whitney U test: z=-1.940, p=0.0524), the opposite takes place in villagers' groups (z=2.076, p=0.0378). The result observed in the villagers' case is in line with the hypothesis that downstream players are expected to allocate less effort than upstream players.

The results are slightly different when considering the effort share, as defined in Eq. 9. In this case, the effort share is insensitive to the position in both students and informed villagers' groups (students: z= 1.751, p=0.0800; non-informed villagers: z=1.897, p=0.0578; informed villagers: 0.605, p=0.5450), implying that the level of effort adjusts to the subject endowment, which also depends on public good provision.

The results suggest that even though public good contribution follows somehow the same trend than the level of effort with respect to the position, both absolute and relative measures of contribution with respect to appropriation payoffs are insensitive to the position except in the students' case. The students' results might be explained by the fact that students' relative contribution with respect to the appropriation payoffs is larger than that of villagers (z=2.174, p=0.0297). As a result, the difference between appropriation and contribution is smaller in the students' treatment, as shown in Figure 6.3.
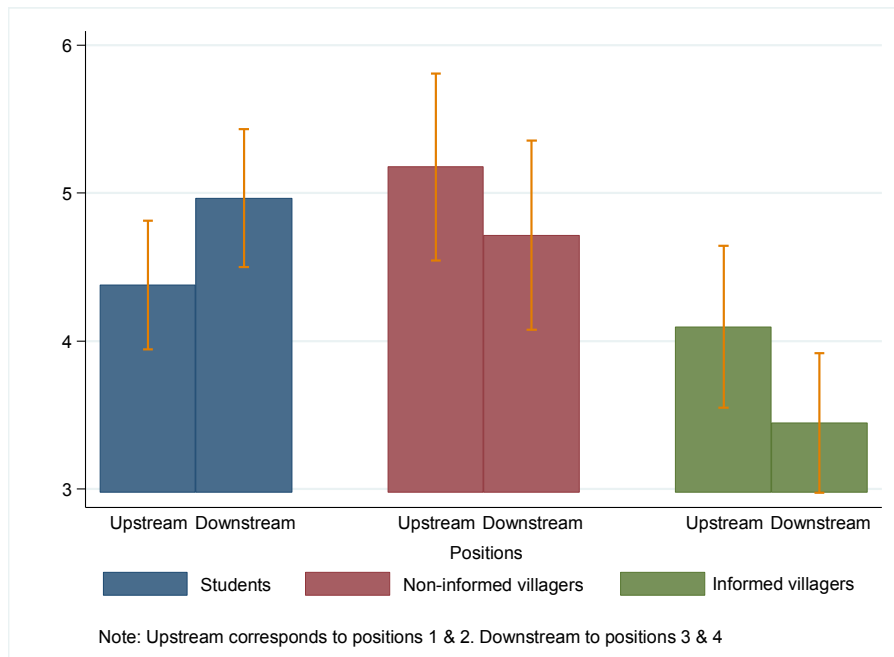
Figure 6.4 Average game effort by player's position and treatment group (points). The error bars indicate the 95% confidence interval for each position in each treatment group.

6.5.2   Individual-level efficiency in the game

Game results can be analyzed on an efficiency basis. For this purpose, we define efficiency as the difference between the social optimum defined by the game benchmarks, $z_i^{S*}= 90$, and the individual game payoffs. The difference between social and actual payoffs is considered an efficiency loss.

Figure 6.5 shows the distribution of efficiency loss by treatment. Average and median efficiency losses, expressed in game points, are (59.31, 60.00), (59.24, 64.00), and (64.71, 67.13) for students, informed villagers and non-informed villagers, respectively. Note that these losses represent up to two thirds of potential benefits, and quite. In the three groups, distribution of losses is skewed to the left. Kruskal-Wallis test suggests that there is not a significant difference in efficiency loss distributions among treatment groups at 5% confidence level ($X^2_{df=2}= 5.866$, p-value= 0.0532). Differences in efficiency loss distribution between students and non-

informed villagers are statistically significant (Mann-Whitney-U test, z= -2.406, p-value= 0.0161). In line with previous results on game earnings, we can conclude that non-informed villagers performed worse than the students. However, Mann-Whitney-U test shows that efficiency distribution between informed and non-informed villagers groups is not significantly different (z= 1.345, p-value= 0.1785).
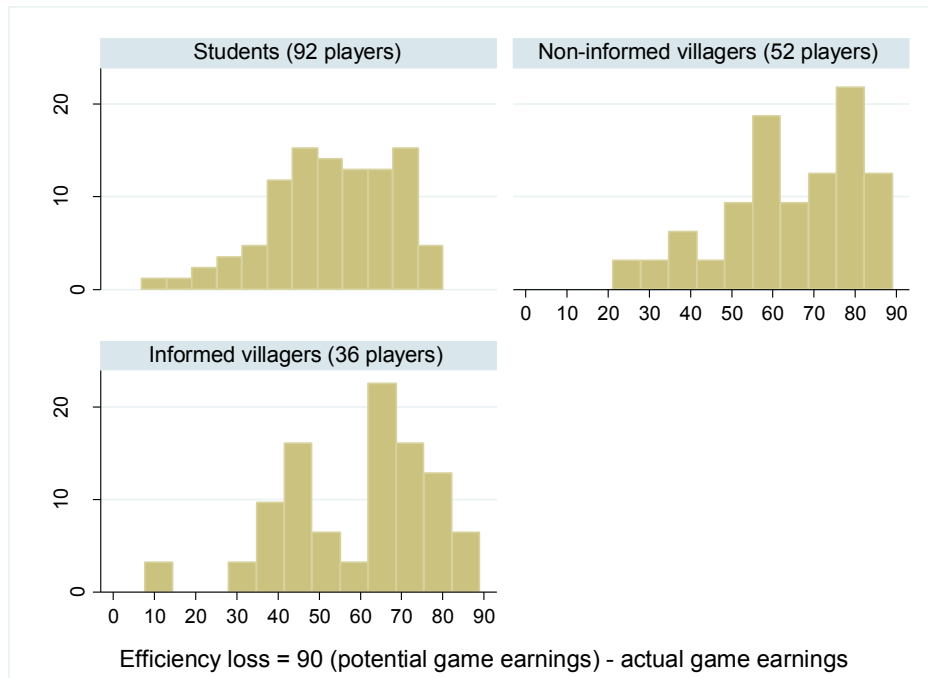
Figure 6.5 Histogram of efficiency losses (in points) by treatment group.

Observation 4. *Lower game efficiency losses are explained by the appropriation behavior within the group, larger willingness to cooperate and a larger share of females in the group.*

There might be different explanations for differences in the efficiency loss. Given our game design, we can test whether smaller losses of individual efficiency are related to early resource depletion, as subjects might deplete the resource by appropriating in early rounds and not contributing to public good provision. However, the Spearman correlation test suggests that the null hypothesis of independence between efficiency loss and the maximum number of rounds reached in the game cannot be rejected (ρ= 0.0652, p = 0.3883).

Furthermore, we are interested in analyzing to what extent individual characterization as either high or low appropriator relates to the efficiency loss. For this purpose, we introduce a new variable named 'appropriator', that is bounded between 0 and 1. For each round, a player gets a score of 1, if his appropriation is above the group's average, and 0 otherwise. Variable appropriator will be the average of the previous counts of 1s and 0s for the entire game. If 'appropriator=1' then the player appropriated more than the group's average in all rounds; if 'appropriator'=0, it means he/she appropriated less than the group's average in all rounds. The

average and standard deviation of 'appropriator' for students was (0.47, 0.34), non-informed villagers (0.51, 0.29) and informed villagers (0.45, 0.29).

Also, individual traits with respect to pro-social behavior might influence individual earnings and, therefore, might relate to efficiency loss. Table 6.3summarizes the variables collected in the survey and included in the analysis, as described in section 6.4.

Table 6.3 Summary statistics of variables measuring pro-social behavior.

	Students			Villagers		
Variable	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Cooperation[a]	91	2.703	1.304	87	2.517	1.119
Trust[b]	91	2.301	1.034	88	2.148	1.012
Altruism[c]	91	2.187	0.942	88	2.091	0.967
Fairness[d]	91	2.648	0.721	86	1.477	0.808
Risk[e]	92	2.563	0.939	88	2.577	0.997

[a] Cooperation ranks from 1 (low inclination) to 5 (high). It is calculated by aggregating the response from willingness to share land (yes=1, no=0) and the quartile position in the contribution to the Voluntary Contribution Mechanism (1-4). [b] In the students' case, trust measures the quartile position in the Trust Game (1-4). In the villagers' case, following Janssen et al. (2012), a trust index is constructed based on the responses to 6 statements. Trust measures the quartile position in the index (1-4). The index is calculated with the formula (B+C-A-D-E-F+14)/18. The statements are: A – most people in this village are basically honest and can be trusted. B – people in this villager are mostly interested in their own well-being. C – In this village one has to be alert, or someone will take advantage of you. D – if I have a problem there is always someone in this village to help you. E – most people in this village are willing to help if you need it. F – if you lose a pig or chicken someone in the village would help look for it or would return it to you. [c] Altruism indicates the quartile position in the amount sent in the Dictator Game (1-4). [d] Fairness is measured on a scale 1 to 3. Value 1 indicates that the person would accept offer 1 in the Ultimatum Game. That is, 25 for him/her and 75 for the sender, out of 100. Value 2 indicates that the person accepts offer 2 (40 for him/her, 60 for the sender). Value 3 indicates that the person would not accept any offer unless the amount is divided equally among the two players. [e] Risk is measured on a scale from 0 (risk averse) to 5.3 (risk lover). Responses to 'accept-reject lotteries' and 'choose lottery' in the students and villagers' cases, respectively, were standardized.

Table 6.4 reports regression results explaining individuals' efficiency loss at the end of the game. We present (1) a model pooling observations for the three treatment groups (i.e. students, informed villagers and non-informed villagers), (2) a model for the three treatment groups including a categorical variable that accounts for group composition in terms of sex heterogeneity (it takes value 1 when men are majority in the group, 2 when there is an equal share of males and females, and 3 when females are majority), (3) a model including a dummy variable that accounts for the type of experiment (students vs. villagers) and (4) a model that includes an information treatment dummy variable. Breusch-Pagan test for heteroskedasticity reveals that we cannot reject the null hypothesis of constant variance in the four models and,

therefore, standard errors estimation is robust (p=0.8838, p=0.2821, p=0.1558, p=0.1172 for model 1, 2, 3 and 4 respectively).

To interpret the signs of the coefficient cogently, note that the explained variable is individual's efficiency loss. As expected, a heavy 'appropriator' has a negative and significant effect on efficiency loss. However, both appropriation and effort shares, as defined in Eqs. 8 and 9, have a positive and significant effect on efficiency loss in model 1. Thus, the larger the share an individual appropriates from the CPR the larger the individual efficiency loss, as individual game payoffs depend both on individual appropriation and the remaining CPR. However, when the group's sex composition variable is included in model (2), the appropriation share coefficient becomes not significant. It is interesting to note that the group composition coefficient takes a negative sign, meaning that as the share of females increases in the group the efficiency losses are smaller. Contribution share, defined as the ratio between public good provision and payoffs from the appropriation stage, shows a significant positive coefficient. Therefore, higher levels of contribution relate to larger losses of individual efficiency. These results are consistent with the *mixed strategy* defined in the game benchmarks, in which the aggregate game payoffs for the group are the lowest, as compared to the individual or social optimums.

Considering individual traits with regards to pro-social behavior, the variable cooperation is negative and statistically significant. Based on the models' results, a higher inclination to cooperate is related to a lower efficiency loss in the game. We do not find a significant effect of trust on efficiency loss, but a positive and statistically significant effect of altruism. As described earlier in the paper, the amount sent in the dictator game is used as a proxy for measuring altruistic behavior. Thus, given the structure of the game, those subjects showing more altruistic responses earn significantly less than those less altruistic.

Fairness, as measured in the ultimatum game, is positive but not significant in models 1 and 2. However, once we include the dummy variable for the type of subject involved in the experiment (student or villager), the coefficient becomes significant. As shown in Table 6.3, students exhibit a higher concern for fairness than villagers as nearly 80% of the students' sample scores 3 on the fairness indicator. Regression results of model (3) also show that the dummy variable controlling for the treatment group is negative and statistically significant, implying that students earn significantly more than villagers and, therefore, efficiency losses are smaller. The variable accounting for the information disclosure treatment is not significant in model (4). However, when considering group-level performance, the results show that informed villagers groups rank lower than non-informed villagers groups in terms of overall group efficiency losses (Mann-Whitney U test, z=3.557, p=0.0003).

Game payoffs are related to a large extent to the effort a player allocates to appropriation. However, there is a trade-off between individual and group appropriation and the efficiency losses. Whereas being a high appropriator correlates with lower individual efficiency losses, as shown in Table 6.4, belonging to a group that appropriates more than an average group is positively correlated to larger group-level efficiency losses ($\rho=0.2549$, p =0.0006). The level of cooperation achieved in effort among group players is intrinsically connected to game earnings and, in turn, to group and individual efficiency. The next section analyzes in greater detail individual effort decisions along the game.

Table 6.4 Regression results for individual data explaining game efficiency losses.

Efficiency loss	(1)	(2)	(3)	(4)
Constant	49.47***	56.48***	56.34***	54.19***
	(5.425)	(6.175)	(6.012)	(6.347)
Appropriator (0=low)	-17.63***	-16.94***	-17.62***	-17.44***
	(3.338)	(3.308)	(3.228)	(3.232)
Appropriation share	5.405**	4.274	4.021	4.536*
	(2.694)	(2.705)	(2.635)	(2.679)
Contribution share	59.99***	58.93***	57.36***	60.18***
	(7.244)	(7.163)	(6.993)	(7.487)
Cooperation	-1.585*	-1.919**	-1.829**	-1.924**
	(0.893)	(0.894)	(0.871)	(0.875)
Trust	0.248	-0.0874	-0.0834	-0.198
	(1.085)	(1.081)	(1.053)	(1.058)
Altruism	2.588**	2.590**	2.516**	2.565**
	(1.154)	(1.139)	(1.109)	(1.110)
Fairness	0.038	0.053	2.564*	2.528*
	(1.098)	(1.084)	(1.333)	(1.333)
Risk	0.872	1.010	0.887	1.030
	(1.074)	(1.061)	(1.034)	(1.042)
Sex composition		-2.702**	-2.806**	-2.819**
		(1.186)	(1.155)	(1.155)
Experiment (0=villager)			-7.847***	-6.425**
			(2.546)	(2.881)
Treatment (0=no info)				3.295
				(3.126)
Observations	165	165	165	165
R-squared	0.409	0.428	0.461	0.465

Note: We used Ordinary Least Squares, and the significance level is reported by adjusted R^2. Standard errors in parentheses*** $p<0.01$, ** $p<0.05$, * $p<0.1$

6.5.3 Explaining effort along the game

Observation 5. *Appropriation effort decisions are path-dependent and respond to CPR scarcity, pro-social factors and group's sex composition.*

Our data generation process allows us to analyze what factors determine individual appropriation effort decisions (x_{it}) along the game. The dependent variable is the

logarithm of the level of effort allocated by an individual i on a certain round t. To capture the effect of previous round outcomes on individual effort decision on round t, we include a number of lagged variables. In addition, we include as independent variables the decreasing rate of CPR available to the subject i in round t with respect to $t-1$, the round, pro-social individual traits and the type of experiment and group composition. The model can be best estimated by using Panel Corrected Standard Errors, correcting for heteroskedasticity and contemporaneous correlation across panels. We used Stata 12.0 and implemented the command xtpcse. We run four models, (1) including the lagged round payoffs variable, (2) in which this variable is excluded and (3) and (4) which add pro-social behavior variables to models 1 and 2, respectively. Results are presented in Table 6.5. In this regression analysis we only include observations for student and villagers without the information treatment as the game design is exactly the same for both types of subjects.

Table 6.5 Regression results for panel data explaining players' logarithm of effort along the game.

Effort	(1)	(2)	(3)	(4)
Constant	1.226***	1.988***	1.375***	2.249***
	(0.109)	(0.088)	(0.149)	(0.130)
Payoffs (t-1)	0.282***		0.245***	
	(0.028)		(0.030)	
Relative appropriation (t-1)	1.056***	1.422***	1.016***	1.292***
	(0.141)	(0.141)	(0.140)	(0.139)
CPR decrease rate	-0.092***	-0.073***	-0.087***	-0.071***
	(0.013)	(0.013)	(0.014)	(0.014)
Round	-0.126***	-0.155***	-0.130***	-0.154***
	(0.009)	(0.008)	(0.009)	(0.008)
Sex composition	-0.119***	-0.134***	-0.127***	-0.160***
	(0.026)	(0.028)	(0.027)	(0.029)
Cooperation			-0.020	-0.062***
			(0.020)	(0.021)
Altruism			0.045*	0.031
			(0.026)	(0.027)
Fairness			-0.050	-0.062*
			(0.034)	(0.038)
Experiment (0=villager)	-0.155***	-0.094*	-0.068	-0.001
	(0.048)	(0.052)	(0.065)	(0.072)
Observations	939	939	924	924
R-squared	0.701	0.663	0.695	0.671
N panels	142	142	139	139

Note: We use Panel Standard Corrected Errors, and the significance level is reported by R^2.Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.

We expect the estimator of the lagged payoffs variable, $z_{i(t-1)}$, to be positive and significant, implying that those subjects with higher payoffs in the previous round would allocate more effort to appropriation in the subsequent period. Model 1

shows that this coefficient is positive and significant. Payoffs coefficient can be interpreted in terms of elasticity, as the variable is expressed in logarithms. Thus, a 1% increase in previous round earnings would increase effort by 0.31%.

As subjects in the group receive information on total group appropriation after they play the Stage 1 of each round, we include a variable defined as the relative appropriation an individual carries out in the previous round with respect to the total group appropriation, x_{it}/X_t. This variable has a positive and significant coefficient, indicating that that those in the group who appropriate more tend to replicate this behavior in subsequent rounds, which has equity effects on the allocation of gains.

In addition to lagged variables, we consider contemporaneous factors such as the CPR decreasing rate each subject faces and the round. CPR decreasing rate is defined as the variation in the CPR available to the player at Stage 1 of the round, $(F_{i(t-1)}/F_{it}) - 1$. We expect the CPR decreasing rate coefficient to be negative as subjects respond to scarcity and, in most cases, the CPR is not depleted. The results show that the coefficient is negative and significant and, therefore, subjects show some concern for scarcity. Thus, once a subject allocates units of endowment to appropriation effort, he will likely contribute more to public good provision, entering a vicious cycle of inefficiency in which the group would need to cooperate to reduce the level of effort. Second, we include the round as a trend variable. The results show that round coefficients are negative and significant and, therefore, subjects reduce the level of effort as the game advances, adjusting to the decreasing CPR trend.

Individual traits are expected to influence effort decisions. However, we find that fairness is not significant and altruism is only significant when accounting for lagged payoffs. Contrarily, cooperation is significant once we exclude lagged payoffs from the model. The negative cooperation coefficient indicates that those individuals who display more cooperative responses allocate less effort to appropriation. This result suggests that the dynamics of the game are relevant for shaping the cooperative behavior of individuals.

As in earlier models, the results suggest that students allocate significantly less effort than villagers to appropriation, but this coefficient is only significant when excluding the pro-social variables discussed above. The level of education might be related to differences in effort levels. However, we observed that education is only significant and positive in model 4 for villagers with an educational degree lower than primary school.

Regarding group sex's composition, the results show that individuals in groups in which females represent a larger share appropriate significantly less than groups in which males dominate in number.

6.6   Conclusions

This paper presents the results of an asymmetric game that combines incentives to make use of common pool resource and to contribute to its conservation (a public good game). Collective action problems related to both common pool resource appropriation and public good provision are typically present in irrigation systems and other common pool resources. The experimental design of this game attempts to reflect this type of irrigation social dilemmas and analyze the behavior of students and villagers in Nicaragua when confronting these decisions. The results reveal that students and villagers display different outcomes, with villagers allocating more units of effort to CPR appropriation than students, which, in turn, affects CPR availability and determines the efficiency of the game. The fact that appropriation and contribution are positively correlated indicates a correspondence in decisions. However, as the marginal benefits from appropriation are above the marginal CPR increase from public good provision, a vicious cycle of inefficiency is created in which the villagers are more likely to fall than students. This suggests that groups' homogeneity, in terms of age and education, favor more efficient game outcomes.

The results suggest that an asymmetric access in sequential order to the resource influences the level of appropriation effort, but not the relative effort share with respect to the subject's endowment.

Disclosing information adds certain transparency to game decisions. In this way, information affects the level of public good provision, with informed subjects contributing less than non-informed players. Thus, information disclosure changes to some extent the strategy players implement, affecting primarily the distribution of outcomes at group level. In this sense, it is important to take into account the equity effects of introducing information disclosure into this type of social dilemmas. In practical terms, concealing individual's behavior information in small groups might be impossible, suggesting that smaller groups may be more vulnerable to decay than larger ones in which anonymity is more possible and only general performance is disclosed. Seeing others' contribution does not guarantee that public good provision will be enhanced.

Key factors regarding efficiency losses are the level of cooperation and group heterogeneity in terms of sex composition. Our results suggest that those individuals who display a more cooperative behavior in the survey show lower efficiency losses in the game. In addition, inclination to cooperate is negatively related to the effort allocated in the game, which, in turn, improves the efficiency in the game. Regarding sex composition, our results show that this is a relevant factor to take into account. Groups composed mainly by females perform better in terms of efficiency, allocating less effort to appropriation than groups in which males represent a larger share. This result might show certain gender relations that would be worth examining in further detail. Subjects respond to endogenous scarcity by allocating less effort to appropriation the larger the CPR decreasing rate, showing sensitivity to

CPR conservation. These results are consistent with previous findings from Osés-Eraso and Viladrich-Grau (2007) and Osés-Eraso *et al.* (2008). However, human-induced scarcity is not enough to foster cooperation in the commons and move toward the social strategy of the game.

Part of the variability in the efficiency and effort results can be explained by norms of cooperation, fairness and altruism. These results might highlight three important outcomes. First, there might be efficiency distribution differences within the group when groups are heterogeneously composed in terms of fairness norms. Second, altruism might influence the level of public good provision and, in turn, drive to more effort and efficiency losses. Third, the inclination to cooperate creates a virtuous cycle of lower appropriation effort and efficiency. Therefore, when promoting collective action in the commons, the initial level of cooperation achieved might be a relevant factor determining subsequent environmental and economic outcomes.

7 Decay of collective irrigation organizations in a post-colonial context: the case of Suriname

Abstract

This chapter aims to identify the factors that may explain the failure of collective irrigation institutions in a context of transition from a colonial to a home-rule government in Suriname. More specifically, the study describes the mechanisms by which institutions, within a specific social-ecological setting, generate the incentives that affect the capacity of users to engage in collective action for the provision of irrigation and drainage services, and contribute to its conservation and management. The results show that the lack of clear operational and collective choice rules creates an institutional vacuum in which rule breaking ends up taking place with impunity. In the case of Suriname, these governance characteristics appear to be rooted in deeper political processes that date back to the colonial period and extend up to the present days. The transition from collective institutions, Water Boards, set up during the colonial period towards a co-responsibility framework failed in its first attempt made by the national government. Our empirical findings suggest that it is necessary to overcome the problems derived from ethnic heterogeneity, poorly defined land allocation and rights, and irrigators' government distrust in order to develop the social capital required for a collective action with equitable and economic efficient outcomes. A second governmental attempt that recognizes the first attempt's failures seems better framed, more supported and better designed. In conclusion, the chances of success are higher.

7.1   Introduction

Agricultural development has been widely recognized as key for economic development and poverty reduction in developing countries (World Bank, 2007; OECD, 2013). Valdés and Foster (2010) indicate that agricultural growth in developing countries contributes to the overall growth of the economy and, in this way, to poverty reduction. As suggested by Ligon and Sadoulet (2007), agricultural GDP growth benefits mainly the poor. In addition, the fact that major advances in poverty reduction have taken place in regions with a larger proportion of irrigated areas highlights the relevance of irrigation for economic development (Lipton *et al.*, 2003). OECD claims "people who have better access to water tend to have lower levels of undernourishment" (OECD, 2013, p.50).

Over the past decades irrigation reforms have focused on the devolution of irrigation management from government agencies to local organizations or users and the strengthening of participatory irrigation institutions (Vermillion, 1997, 2001; Faurès *et al.* 2007). As stated by Meinzen-Dick *et al.* (2002), underperformance of irrigation systems under government operation jointly with fiscal constraints fueled policies that attempted to transfer irrigation management to the growers and their associations. However, in those countries where significant subsidies existed before the management transfer, the operation and maintenance cost for farmers may rise substantially (Vermillion, 1997). As a result, investment in operation and maintenance activities has decayed in many cases, leading to systems' deterioration and abandonment of collective irrigation infrastructure. For example, at the end of the 1980s, Mexico had lost one fifth of its irrigated land because of the lack of proper maintenance (Garrido, 2002; Molle and Berkoff, 2007).

Collective action for irrigation management has been promoted in Suriname since the early 1930s. Inspired in the model of Dutch Water Boards (WBs), a polder system was developed in the coastal plains of the Northwestern part of the country. However, after 1970s and the independence of Suriname from The Netherlands in 1975, there was a gradual abandonment of collective irrigation systems and WBs. Recently, since 2005 the Surinamese government has included the management and maintenance of irrigation systems, particularly in the rice growing areas, back in the policy agenda. New legislation was enacted in 2007 that provided the legal framework for the revitalization of WBs. A total of 14 WBs have been established under this scheme in the country, but most of them are not functioning as expected, and some are still in the process of drafting and approving their by-laws. However, the creation of the WBs under the 2007 legislation was not followed up by any significant change in terms of devolved management or participation. In fact, the process completely failed as committees were not formed and elected committees soon abandoned their responsibilities. In a second attempt, begun in 2011, the government has established programs to train elected representatives, and actively

support and steer the devolution process with a view to avoid the barriers found before.

So far, WBs revitalization has been mainly supported by EU funds. Thus, as part of the government effort to boost agricultural production, the EU funded a program to "Support the Competitiveness of the Rice Sector in the Caribbean", which was implemented between 2004 and 2010. This project has been followed up by investments on capacity building in irrigation and water management[11]. More recently, the Government of Suriname has requested the technical support of the Inter-American Development Bank (IDB) to help design and implement a medium term investment and policy reform oriented towards improving provision of public agricultural services, modernizing land management and drainage and irrigation management systems and increasing capital investments in public productive infrastructure.

In the absence of a powerful government agency with competencies in water and irrigation, it is believed that a bottom-up approach will revitalize a sector that just a decade ago was twice as big as it is presently. However, strong government support at the local level might not be sufficient to trigger self-governance and robust water institutions. In the case of Suriname, this task not only has to erect and revitalize newly created institutions by home-rule and foster farmers' cooperation, but also revert the deconstruction process over the past decades, and all the losses it entails. Therefore, it is important to examine what additional factors would need to be strengthened for collective action in the irrigation sector.

By identifying the factors that may explain the failure of collective irrigation institutions in Suriname, our general objective is to study the mechanisms by which institutions, within a specific social-ecological setting, generate the incentives that affect the capacity of users to engage in collective action for the provision of irrigation and drainage services, and contribute to its conservation and management. The particular case of Suriname provides an interesting setting for examining the emergence and deconstruction of collective action along a transition from colonial to home-rule government and how social-ecological factors linked to this process influence the performance of collective irrigation institutions.

The chapter is organized as follows. Section 7.2 provides a brief description of Suriname's irrigation sector. Section 7.3 develops the theoretical basis and section 7.4 describes the empirical strategy. Section 7.5 and 7.6 contain the main results and conclusions, respectively.

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[11]Capacity Building for Integrated Water Management in Nickerie, West Suriname. WATERNET, Funded by the EU.http://www.owmcp.org/project---capacity-building-for-integrated-water-management-in-nickerie.html

7.2   The irrigation sector in Suriname

Water for irrigation is mainly used for rice cultivation in the Nickerie district, in the Northwestern part of the country (see Figure 2.3), where nearly 90-95% of rice production is concentrated. In this district, sown area in the current season covers 24,000 ha, which is half of the rice cultivable area. In the Nickerie district also stands the city Wageningen and the old Stichting Machinale Landbouw (SML, *Mechanized Agriculture Foundation* in English), a processing plant developed by researchers from Wageningen University (The Netherlands) in 1949. The original SML covers 10,000 ha of paddy rice production. However, after the independence in 1975, SML was transferred to the Suriname's government and eventually collapsed. Nowadays, only 2000 out of the 10,000 ha are being cultivated by previous SML workers and 3000 ha are not under cultivation. The remaining 5000 ha are state-owned.

Rice production in the Coronie district, nearby Nickerie District (see Figure 2.3), has been abandoned in the last years. However, there are 4000 ha available for paddy rice cultivation. Nearby the rice paddies, there are coconut trees that use drainage water from rice irrigation. In the Saramacca district, next to Coronie and closer to the capital, paddy production extends over 1000 ha. Table 7.1 summarizes rice production areas in the current season and the potential areas available.

Table 7.1 Rice area cultivated and potentially cultivable (ha).

District	Rice area (ha, current season)	Rice cultivable area (ha)
Nickerie	26,000	50,000
Coronie	200	4000
Saramacca	1000	3500
Total	27,200	57,500

Source: Based on the interviews with 1) District Commissioner of Coronie and 2) Regional Coordinator of the Ministry of Agriculture for Nickerie and Coronie.

Polder cultivation systems were developed for rice production. Historically, WBs were in charge of managing irrigation and drainage systems in the polders. WBs, named "Waterschappen" in Dutch, were developed during the colonial period and date back to the 1930s.   However, after the country independence, WBs were progressively abandoned until 2005 when a new Water Board law was enacted in the country and the government initiated a process of WBs revitalization under the EU funded project CARIFORUM. As a result, 14 WBs were projected in Wanica and Nickerie districts. Up to date only 6 of these WBs have been created formally[12], but none of them is currently under active operation. Thus, maintenance of irrigation and drainage systems is mostly in the hands of the government. Table 7.2 provides a list of the WBs, and includes basic data describing its specific characteristics. An

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[12] By that, we mean that a formal Keur has been issued establishing its limits, roles and responsibilities.

outstanding feature in all of them is the number of farmers, and the small average size of their farms.

Table 7.2 List of Water Boards.

N	Water Board	Area (ha)	N parcels	Main crop	N farmers
1	Henarpolder	2242	605	Rice	598
2	Europolder-Noord	1035	164	Rice	160
3	Corantijnpolder	747	573	Rice	573
4	Sawmillkreekpolder	481	219	Rice	97
5	Hamptoncourtpolder	894	591	Rice	540
6	Van Drimmelenpolder	850	568	Rice	568
7	Clarapolder	1366	455	Rice	365
8	Uitbr. Gr-Henarpolder 1 & 2	1804	172	Rice	-
	Europolder-Zuid	1140	214	Rice	214
10	Paradise & Longmay	980	922	Rice	536
11	Nanni&Brutopolder	1447	266	Rice	262
12	Wasima (Waldeck,Sidoredjo& Margarethenburg)	352	370	Rice	-
Total		13,438	5119	Rice	-
13	Overliggend Waterschap MCP	31,198		Rice, banana and others	-
14	Reeberg	700	46	Animal husbandry	-

Source: MRD (2013) and Naipal (2005).

Currently, three Ministries have competencies in the management of irrigation and drainage systems. The Ministry of Public Works is responsible of the construction and maintenance of the primary roads, irrigation and drainage canals, sluices and other infrastructural works. The Ministry of Agriculture is also involved in the maintenance of primary infrastructure in the relatively new polders (in total 18,110 ha) and the supply of water for irrigation. Lastly, the Ministry of Regional Development is in charge of the construction and maintenance of the canals that are not under the responsibility of either the Ministry of Public Works or the Ministry of Agriculture. However, in practical terms, the boundaries among the three ministries are not in all cases well-defined. Each, in turn, has its own budget and carries out repairing and investment works separately from the others.

Under the government plan of revitalizing WBs, the Ministry of Agriculture is in charge of setting up the irrigation infrastructure so that the WBs can take on the management subsequently. The Ministry of Regional Development is also involved in this task, as it is the government body responsible for the approval of WBs' regulations, including the operational by-law (called "keur" in Dutch). However,

although the infrastructure of some WBs has been renovated, the Ministry of Regional Development has only approved the by-law of one of them.

In addition to assure cost-recovery of irrigation and drainage systems, one of the challenges WBs face is to improve rice productivity. As shown in Table 7.3, on average, Suriname has a yield gap if compared with Central America and South America averages of 4.2 ton/ha and 5.3 ton/ha in 2011, respectively (FAO, 2013). In addition, average yield in Suriname is lower than in neighboring countries such as Guyana and Venezuela. The yield gap is similar when considering the top 5 world rice producers in 2011.

Table 7.3 Rice yield in Suriname, top-5 producer countries in 2011 and Latin American & Caribbean regions (ton/ha, period 2006-2011).

Region	Country	2006	2007	2008	2009	2010	2011
	Suriname	4.1	4.3	4.2	4.2	4.2	4.1
Top-5 producers	China	6.2	6.4	6.6	6.6	6.5	6.7
	India	3.2	3.3	3.3	3.2	3.4	3.5
	Indonesia	4.6	4.7	4.9	5.0	5.0	5.0
	Bangladesh	3.9	4.1	4.1	4.2	4.3	4.2
	Vietnam	4.9	5.0	5.2	5.2	5.3	5.5
Neighboring countries	Venezuela	5.0	5.1	5.2	5.0	5.0	5.7
	Guyana	4.6	4.3	4.2	4.4	4.2	4.8
	French Guiana	1.7	2.3	2.3	2.3	2.2	2.5
Latin America & Caribbean	Central America	3.6	3.5	3.8	3.8	4.1	4.2
	Caribbean	3.6	3.8	3.6	2.7	2.7	2.8
	South America	4.5	4.5	4.8	4.9	4.6	5.3

Source: Based on FAO (2013).

Also, as Figure 7.1 clearly shows, the production and area harvested are significantly lower than in the 1980s where they peaked. Yields have remained quite stable since the 1980.
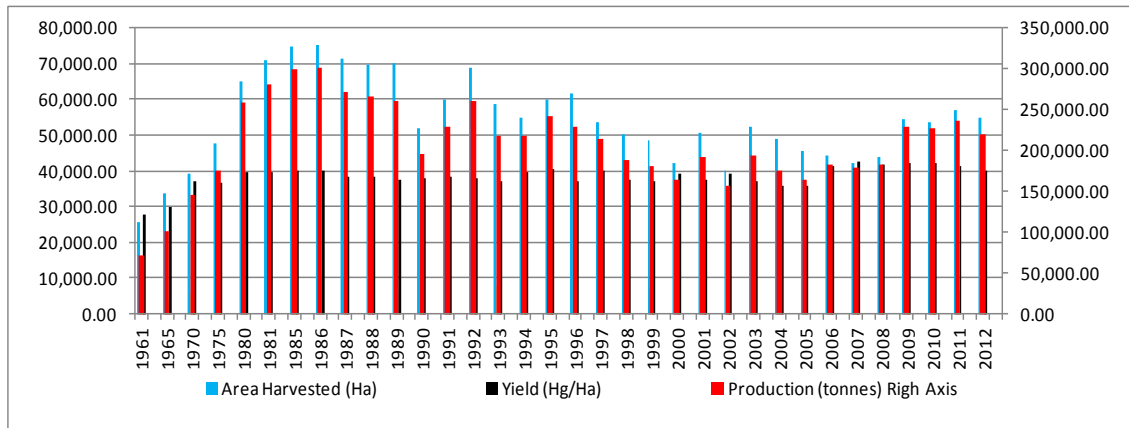
Figure 7.1 Area harvested of rice, yields and production of Suriname (1961 - 2012). Source: FAO (2013)

7.3   Theoretical framework

The capacity of individuals to solve collective action problems in common-pool resource settings depends on different factors related to both humans' and ecosystems' characteristics (Agrawal, 2001; Ostrom, 2007b). Thus, provision of irrigation and drainage services depends on the incentives that people have to appropriate water resources and contribute to systems' maintenance. Irrigation systems are a typical example of resources managed under a common property regime as "there is a well-defined group whose membership is restricted, there is an asset to be managed (…), there is an annual stream of benefits (…), and there is a need for group management of both the capital stock and the annual flow (…) to make sure that the system continues to yield benefits to the group" (Bromley, 1992, p. 14).

Provision of public infrastructure, as irrigation and drainage systems, is affected by the non-excludability of the generated benefits and the free rider problem (Ostrom *et al.*, 1993). In rice paddies, where flooding and drainage operations are made for large sections of irrigation projects simultaneously and water consumption is rarely metered, the free riding problem may be even more acute. As many people can benefit jointly and simultaneously from public goods, and exclusion is very often too costly, there are few incentives to provide this type of services. Non-excludability makes pricing difficult, which can lead to free-riding and underinvestment in capital and maintenance (Olson, 1965; Ostrom *et al.*, 1993).

When others who did not contribute to the provision of the good can enjoy the benefits of providing a collective good, there are incentives for free-riding on the effort of others and providing a sub-optimal level of the good. Under these circumstances, Olson (1965) argues that collective action is likely to fail. As discussed in chapter 3, traditional economic theory has predicted that, without external intervention, a group of rational individuals would not cooperate to

overcome common pool resource dilemmas and would tend to overharvest the resource, as described in Hardin's "tragedy of the commons" (Hardin, 1968).

However, the empirical literature on the commons points to a number of factors that explain successful collective action in managing CPRs. Thus, a small group of users, a high level of dependence on the resource, low monitoring costs and appropriate mechanisms for sanctioning are generally related to more effective conservation of CPRs (Wade, 1988; Ostrom, 1990; Baland and Platteau, 1996; Agrawal, 2001). In this line, theoretical explanations of collective action suggest that the number of decision makers, the minimum number of participants necessary to attain collective benefits, the discount rate (i.e. how individuals value the future with respect to the present), the existence of similar interests and the presence of leaders or participants with substantial assets are key variables influencing cooperation in the commons (Ostrom, 1990).

In addition to internal variables, Ostrom (1990) argues that external factors related to the political regime in which CPRs users live influences their capacity for self-organization. Thus, for example, in her analysis of irrigation systems in Sri Lanka, unwillingness of the central regime to enforce rules and the capacity of those who want to avoid rule enforcement to influence government officials undermined collective action institutions.

From a political economy perspective, Roland (2002) acknowledges the relevance of political and sociological variables in defining institutional choices in transition, as well as how these influence in the economic policies. In this respect, he argues that the economic transitions are intimately linked to institutional transformations. Similarly, Theesfeld (2004) analyses the constraints on collective action for irrigation in Bulgaria, as an example of a transition economy. By combining collective action theory and transition economics theoretical discussions, Theesfeld (ibid.) suggests that transition-specific features, namely, the incongruity of formal and informal rules, power abuse and information asymmetry and deterioration of social capital, pave the way for opportunistic strategies and hamper self-organization for collective irrigation.

Microsituational variables characterizing the action situation shape individual choices and outcomes in managing CPRs. In this respect, institutional choices can be analyzed in light of the benefits, the costs of changing the status-quo rules and the monitoring and enforcement costs (Ostrom, 1990). Poteete *et al.* (2010) summarize the most frequent variables associated to collective action outcomes related to natural resources. In terms of the social-ecological systems (SES) framework developed by Ostrom (2007b, 2009), these variables are decomposed into the resource system (size, productivity and predictability of system dynamics), the resource units (resource unit mobility), characteristics of users (number, socioeconomic attributes, leadership, norms/social capital, knowledge of social-

ecological system and importance of resource) and the governance system (collective-choice rules). Previous studies identified that performance of collective action in irrigation systems is mainly associated with water scarcity, distance to the market, the number of appropriators and size of the farm holding (Meinzen-Dick *et al.*, 2002; Araral, 2009).

In this study, we rely on the SES framework presented in Ostrom (2007b, 2009) and further developed in Poteete *et al.* (2010) to account for the effect of microsituational variables on the capacity of participants to cooperate in action situations. In addition, following Meinzen-Dick (2007), we include the second-tier variables relevant for the analysis of irrigation institutions. Microsituational variables impact individuals' decision on cooperation in social dilemmas by affecting the levels of trust and net benefits from collective action (see chapter 3 for a more detailed discussion). The framework presented in Figure 7.2is used to organize the variables that can affect the patterns of interaction and outcomes observed in irrigation and drainage systems in Suriname.

Institutional changes at the microlevel are usually incremental and require a minimum level of social capital in order to build trust and establish credible commitments among the participants (Ostrom, 1990). Transitions from colonial to post-colonial status entail changes at multiple levels in the governance system and in the economy. In Suriname, as previously mentioned, WBs were developed under Dutch rule during the colonial period. A more detailed look at the Surinamese history reveals that after slavery abolition in 1863, workers from India and Java (Indonesia) were relocated to sustain the plantation economy established by the Dutch colony. After the termination of their contracts, most plantation workers established small farms oriented toward rice, vegetable and fruit production (Struiken and Healy, 2003). Current settlement patterns still reflect historical settlement developments highly influenced by ethnic origin. Ethnic origin has also had an influence on politics after the independence, with political parties drawing their support from specific ethnic groups (Singh, 2008). In this respect, agriculture and, in turn, irrigation organization are intrinsically linked to the institutions developed during the colonial and post-colonial period, which largely determined land and labor allocation. In addition, Suriname's independence was followed by democratic and authoritarian regimes, which were still very dependent on Dutch economic support (ibid.).

Resource system (RS)
RS1 – Sector: water; RS2 – Clarity of system boundaries; RS3 – Size of water system*; RS4 – Water infrastructure; RS5 – Water scarcity*; RS6 – Equilibrium properties; RS7 – Water supply predictability*; RS8 – Storage characteristics; RS9 – Location

Governance system (GS)
GS1- government organizations; GS2 – Nongovernment organizations; GS3 – Network structure; GS4 – Property-rights systems; GS5 – Operational rules; GS6 – Collective-choice rules*; GS7 – Constitutional rules; GS8 – Monitoring & Sanctioning processes

MPCR MS1   Security MS2   Reputation MS3   Time Horizon MS4

Heterogeneity MS10   Expected benefits Expected costs → Institutional choice → Outcomes   Exit MS5

MS9 Sanctions allowed   MS8 Outcome Information   MS7 Group size   MS6 Communication

Resource units (RU)
RU1 – Resource Unit mobility*; RU2 – Water availability; RU3 – Hydrologic interaction among units; RU4 – Economic value (water/outputs); RU5 – Size; RU6 – Distinctive markings; RU7 – Spatial and temporal distribution

Users (U)
U1 – Number*; U2 – Socioeconomic attributes*; U3 – History of irrigation; U4 – Location; U5 – Leadership/entrepreneurship*; U6 – Norms/social capital*; U7 – Knowledge of irrigation*; U8 – Dependence on the resource*; U9 – Technology used

Related Ecosystems (ECO)

Figure 7.2 SES broader variables and microsituational (MS) variables influencing collective action in irrigation and drainage dilemmas. Note: *Variables frequently associated with collective action in the commons. Source: Based on Meinzen-Dick (2007), Ostrom (2007b, 2009) and Poteete *et al.* (2010)

7.4   Empirical strategy

This research adopts a qualitative approach to study the factors that might explain the origins of the demise of collective action in Surinamese irrigation, as was designed by the Dutch colonial rule, and analyze the difficulties to revitalize it and give a better future under more comprehensive and integrative models. For this purpose, the study focuses on the perception and knowledge that different stakeholders have about the decay of WBs. Therefore, in this research stage, the approach is mostly interpretative. In this respect, it is worth noting that results from the interviews are framed within interviewees' action context and, therefore, they respond to their perceptions in the sphere of present activities and programs, though most likely influenced by the recent history of Surinamese irrigation and drainage policies. Qualitative research is used in order to analyze the problem in its natural context and from the stakeholders' perspective. The methods frequently used in this type of research are interviews, observation and document analysis, which jointly provide our basic data sources.

As previous documents have already analyzed, some of the difficulties for the operation and management of irrigation systems and of WBs, as operational and participatory entities, we primarily relied on these sources for the document analysis. Table 7.4 reports the documents analyzed based on the variables presented in Figure 7.2. A reiterated conclusion that can be found in the documents is that institutional

failure, lack of leadership and the inability of governments to avert the long-term and gradual deterioration are the three main factors explaining the situation that prompted the first Government's response in 2005.

Table 7.4 Documents analyzed in this study.

	Document	Reference	Type of analysis
1	Rehabilitation and completion of the irrigation and drainage infrastructure in Nickerie	Naipal (2005)	
2	Organization and Management Aspects of the Rice Industry in Suriname	Poerschke (2005)	
3	Costs and Benefits of Support Systems in the Rice Sector of Suriname	Graanoogst (2007)	Content analysis based on the variables identified in Figure 7.2
4	Planning and Drainage for Developing the Rice Sector in Suriname	Mertens (2008)	
5	Master Plan for the Supply and Distribution or Irrigation Water for Agricultural Production in the Nickerie District	HTSPE (2009)	

As interviews allow us to capture the perceptions of those involved in water resources management, they have been the major research tool and data source used in our study. We carried out a total of 15 in-depth and semi-structured personal interviews with representative actors from government organizations, research centers, users and consultants somehow involved in the revitalization of WBs in Suriname, as summarized in Table 7.5. It is worth noting that the number of interviewees (24) surpasses the number of interviews (15) as, in some cases, more than a single stakeholder participated in the interview.

Most interviews were carried out in February 2013 in Suriname, except for four of them, which were carried out through phone calls in April and May 2013.Interviewees from government organizations included representatives from the Ministry of Agriculture, Public Works, Regional Development and Natural Resources, as they are the major players within the water and irrigation sector in Suriname. The research centers included the heads of the two major national institutes on agricultural research. The users' group comprised interviewees from a farmers' union and two producers' organizations. Lastly, two consultants working on the irrigation sector were also interviewed.

Table 7.5 List of interviews.

Stakeholder	N interviews	N interviewees
Government organizations	8	11
Research centers	2	3
Users	3	8
Consultants	2	2
TOTAL	15	24

The sampling method was not random, but intentional with the objective of collecting the views from the people involved in different aspects of irrigation, as policy-making, research and management. The interviewees list was elaborated according to the current organizational map of the irrigation sector and based on the advise of a key national consultant in Suriname, who was not included in our sample but helped us identify the key individuals for the interviews.

Qualitative content analysis was used to analyze the empirical material gathered from the documents and the interviews. For this purpose, interviews and documents were coded according to the second-tier variables presented in Figure 7.2. Basic statistical analysis is presented in the following section.

7.5   Results

The results presented in this section combine the analysis of the documents listed in Table 7.4 and the information gathered from the interviews. The results are organized into four observations, following the conceptual framework presented in Figure 7.2.

Because of the empirical strategy, the results presented along these lines focus mostly on the broader SES contextual factors. However, these factors have a direct impact on the microsituational variables that shape individual choices.

7.5.1   Social, Economic and Political Setting

Observation 1. *Market factors and demographic trends inherited from the colonial period made agriculture less attractive, decreasing investments in irrigation.*

Market and demographic factors are summarized in Table 7.6. At the macroeconomic level, a number of processes are highlighted in relation to the rice and irrigation sector. Thus, at the global scale, the rice sector in Suriname has suffered from the price drop in the international market, the change in the EU policy on rice imports and the new WTO regulations. While in the 1970s higher international rice prices fostered investments in the sector, the price drop afterwards made the sector less lucrative and, therefore, less attractive for investors (see Figure 7.3).
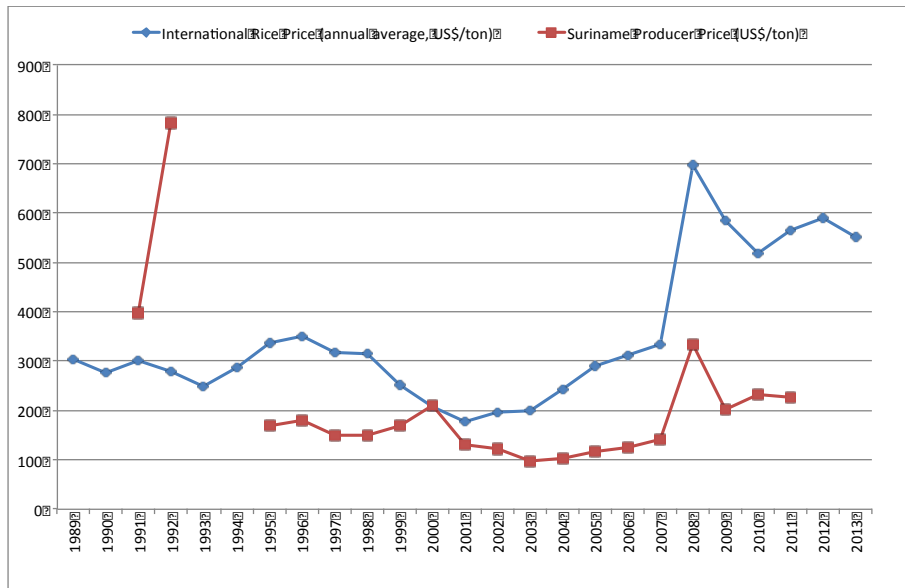
Figure 7.3 International and Suriname Producer Rice Price, US$/ton. Source: Own elaboration based on FAO (2013).

At the local or national scale, the high interest rates of loans resulted in farmers' indebtedness and lower capacity for smallholders to invest in agriculture (current interest rates oscillate between 11 and 18% annually, personal communication). In addition, the increase of input prices, related to some extent to the macroeconomic crises and the exchange rate, made irrigated agriculture less competitive in comparison to other sectors of the economy. Furthermore, after independence, the research program on the rice sector, which included plant breeding activities, post-harvest technologies, and marketing, was significantly reduced, contributing to the drop in rice export prices.

An issue that also emerged along the interviews is labor scarcity in the agriculture sector. Because of better options in the non-farm sector, most young people do not want to work in the agricultural sector. In the words of a farmer "everybody wants to be employed by the government. If we would have had another option, we would not be in the farm sector". This comment brings about two interesting aspects: on the one hand, the major role of the government on the labor market; on the other hand, the labor scarcity in the agriculture sector (i.e. high labor costs) increases production costs in a scenario of lower competitiveness, as compared to other countries. In addition, part-time agriculture plays nowadays a major role in agriculture production in Suriname, as acknowledged in six out of the 15 interviews.

Table 7.6 Market and demographic factors identified in the interviews and documents' analysis

Variable	N responses (interviews and documents)
S1 Economic development	
S1a Macro crisis after independence	3
S2 Demographic trends	
S2b Aging farmers	3
S2b Settlement patterns (ethnicity)	1
S3 Political stability	
S3b Internal war in the 1980s	1
S6 Market incentives	
S6a Increase input costs (fuel prices)	3
S6b Drop in commodity prices	3
S6c Change EU/WTO regulations	1
S6d High labor costs	4

Demographic trends have been also recognized as a factor affecting collective action (Ostrom, 2007b). Both farmers and representatives from the Ministry of Agriculture highlighted the aging of farmers. Ethnicity issues were also raised in the interviews. Thus, settlement patters in Suriname respond to a large extent to historical settlement developments during the colonial period. For example, rice production in Nickerie is largely in the hands of Hindustani people, while black and creole population mainly populates the District of Coronie. In this respect, ethnic heterogeneity might add complexity to collective action problems; in particular, regarding land allocation and land transfer policies across districts and ethnic groups. For example, an interviewee recognized that "in Coronie they do not let *other* farmers rent there".

Another aspect related to demography is the emigration process once Suriname got its independence from The Netherlands. A large flow of people left the country, which has affected agriculture at least in two senses. Firstly, facilitating informal credit to relatives who remained in Suriname. Secondly, aggravating some land tenure problems, as some land plots are still undivided and belong to different owners, being some of them abroad.

7.5.2 Governance system

Observation 2. *The transition from a colonial to an independent country favored the emergence of free-riding behavior due to the lack of shared norms and poor rule enforcement in the irrigation sector.*

Both documents and interviews point out to a range of governance system problems for explaining failure for self-organization in irrigation and drainage systems. Governance system features are unpacked into second-tier variables inTable 7.7.With respect to government organizations, different documents identify the need

for more human and technical capital at government organizations. As a matter of
fact, two interviewees mentioned that, although irrigation depends on the Ministry
of Regional Development, no one at this Ministry has been trained on irrigation
issues. In this sense, two interviewees also highlight that WBs were originally
located under the Ministry of Agriculture, but in 2007 were transferred to the area of
competencies of the Ministry of Regional Development with the objective of using
WBs and polders as a decentralized unit for broader policies at the local level.
However, most farmers and water managers seem to prefer the previous governance
structure as irrigation specialists still work in the Ministry of Agriculture. Lack of
human capital was also highlighted in the case of the Ministry of Public Works. One
interviewee stated that "we were 140 (personnel) in the 1980s, less than 40 today and
only one person with university degree". The human capital of people in
organizations plays a key role as they are directly involved in the devise and
enforcement of rules affecting water sector performance (Madrigal *et al.*, 2011).

Table 7.7 Governance system factors identified in the interviews and documents'
analysis.

Variable	N responses (interviews and documents)
GS1Goverment organizations	
GS1a Low human capital	3
GS1b Lack of coordination mechanisms	9
GS1c Irrigation sector re-structuring	2
GS4 Property rights	
GS4a Land tenure problems	6
GS4b Unclear property rights for common infrastructure	2
GS4b No water rights (open access)	2
GS5 Operational rules	
GS5a Unclear operational rules-in-use	9
GS6 Collective-choice rules	
GS6a Unclear government responsibilities	4
GS6b Unclear rules WB functions / roles	4
GS7 Constitutional rules	
GS7a Incongruence between formal rules – rules-in-use	3
GS8 Monitoring and sanctioning processes	
GS8a Lack of monitoring	4
GS8b No enforcement of sanctions	5

In addition, six out of the 15actors interviewed and three out of the five documents
reviewed recognize the lack of coordination between the government bodies in
charge of water supply and drainage and canals' maintenance. In this respect,
discrepancy between water management plans and outcomes in terms of water
allocation creates problems of water security. If farmers are uncertain about water
supply, collective action is a challenging task as appropriators have more incentives
to act independently. It is worth mentioning that rice crops are flooded, using water

as a mechanism for weed control in addition to irrigation. Therefore, farmers are likely to use as much water as they can when provision problems are likely to occur on the supply side. However, the combined actions of individual farmers often go beyond the technical and hydrological limits, with the result that many plots can neither be planted nor harvested. This is a waste of land and productive capital.

Issues related to the system of land property rights and the rules governing water resources receive a large attention both in the documents and in the interviews. In relation to property rights, the document analysis reveals that a few factors have hindered productivity growth and investment. Landownership issues have generally remained unresolved, land allocation or land transfer policies have been in many cases not transparent. The lack of effective application of the law has resulted in deficient land use planning and, in turn, in water use problems. Many landowners that inherited land migrated mostly to The Netherlands, whose whereabouts are unknown and difficult to identify. So, a significant proportion of the paddies are used by relatives or neighbors who cannot obtain formal titles. As a matter of fact, there are uncontrolled allotments of land for urbanization and a large gap between the available water for irrigation and the total rice area developed under unplanned and uncontrolled initiatives. In addition, illegal occupation of embankments and stabilizing banks results in difficult and expensive inspection, exacerbating free-riding, water overuse and often insufficient maintenance and weeds control.

Land tenure problems have also been widely recognized by the interviewees. A large share of land remains undivided, which makes difficult for farmers to access credit as land is used as a loan collateral. Land tenure problems also relate to the migration process, as previously commented. In addition, as recognized by a farmer in relation to waterways maintenance "in no one land, nobody is responsible for maintenance". This comment illustrates the type of problems that can emerge from the absence of clear property rights. Regarding water rights regime, two interviewees acknowledged that there is not a water rights system in place and water is *de facto* an open access resource. Furthermore, for most of the interviewees the mere notion of creating water rights wrongly evokes a process of water privatization.

Similarly to poor land rights definition, when considering the definition of responsibilities and/or the boundaries of these responsibilities, the lack of clarity in defining constitutional, collective and operational rules creates the space for inaction (i.e. the government of nobody). Operational rules define the set of working rules that affect day-to-day decisions and activities governing water systems, which includes, operation, maintenance and finance, among others. With two cropping seasons, the operations of flooding and draining must be performed in a timely manner to ensure the crops' establishment and tillage operations. But HTPSE (2009) described water management as an "anarchy" as water management rules are not being applied in practice. In addition, the fact that there is not a systematic planning

of operation and maintenance activities increases the uncertainty with respect to the water supply and increases the likelihood of opportunistic behavior.

A reason behind the decline of the cultivated rice paddies is that available water is not sufficient to flood and drain all plots at the right time. Furthermore, since plots are poorly leveled, peak flow demands exceed 2.2 l/s/ha, whereas 1.75 is standard flow. While a water table of 100 mm is normally sufficient to control weeds, in an unleveled plot this could reach 150-200 mm to reach the highest points. Other strategies to save water, including recycling water, pumping from drains to a recycling reservoir, use of the Alternate Wetting and Drying method and plots consolidation have been proposed but not implemented.

Collective choice rules define the management and operational activities, while constitutional rules determine who is eligible to design collective rules. Collective choice rules granting users autonomy for the design of their operational rules have been highlighted in the literature as a key factor for self-organization (Poteete *et al.*, 2010). All documents agree on the lack of clear legislation with a functional legal framework. Rights and obligations of WBs seem to be not clearly defined and responsibilities of the different ministries involved in the water sector are diffuse, resulting in poor coordination among the parties and administrative bottlenecks. In addition, as found in Theesfeld (2004), the incongruity between formal rules and rules-in-use creates an institutional vacuum that favors opportunistic behavior, creating a feedback loop between incongruity in rules and farmers' strategic behavior.

A related aspect to both constitutional and collective choice rules is accountability and the mechanisms that are in place to assure both upward and downward accountability in government and non-government organizations. Different studies on decentralization reforms suggest that downward accountability is one of the most relevant factors that allows local populations to benefit from these reforms (Agrawal and Ribot, 1999; Ribot *et al.*, 2006). Because relationships between existing organizations needs clarification, accountability mechanisms are weak, in particular when considering the mechanisms through which farmers are capable of holding government organizations and WBs accountable, as highlighted by one of the interviewees.

According to the interviews, farmers recognize that "WBs do not work because there are not clear rules on how to function…we don't know what to do. As a result, we cannot charge the farmer for illegal behavior". This lack of rules or institutions is also reflected in the absence of a calendar that takes into account jointly sowing dates, sown area and water availability. As a result, some farmers might be confronted with a situation in which they have sown a certain cultivation area but do not have the water required for irrigation, creating some "conflicts between farmers for water distribution".

A final aspect related to the governance system is monitoring and sanctioning processes. In addition to the factors already mentioned and connected to the lack of clarity in the water legislation, the documents suggest that monitoring is clearly influenced by the characteristics of the water infrastructure. On the one hand, deficient or, in some cases, inexistent access roads make difficult an adequate monitoring of activities, measuring of water abstractions and control of land occupation. On the other hand, insufficient water control structures do not allow for proper water allocation and measurement. In terms of one interviewee, "in the past there was better control, but water control mechanisms have been deteriorated or even destroyed by farmers". In addition, it is worth taking into account the following comment illustrating the impunity of rule breaking: "there are no sanctions if someone does not respect the water turns".

An underlying aspect that relates to some of the issues mentioned above is the process of decolonization. In the 1950s and 1960s WBs played a major role in water management and maintenance, as indicated in the land lease agreement or in the landowners papers. However, after the 1970s, with the new rice varieties, it was possible to sow two seasons and some farmers started to skip one season of maintenance (HTPSE, 2009). Because farmers were a strong stake in some districts, sanctions were not effectively applied (see comment above), which increased free-riding, made farmers more reluctant to pay for water distribution and eroded water managers' skills as WBs were less powerful.

7.5.3   Resource system

Observation 3. *Key attributes of the resource and the state of infrastructure make cooperation more costly for farmers.*

As shown in Table 7.8, some of the features of the resource system and resource units are associated with the failure of collective irrigation. In this respect, the most mentioned factor, particularly by government actors, is the deterioration of infrastructure and the need for further investments in physical capital. Notably, there is a mismatch between water storage and cultivation potential and current infrastructure is not well adapted to the environmental context (i.e. considering rains, tides and saline intrusion).

Climate change is also threat for agricultural sustainability and expansion. A recent report[13]suggests the following adaptation measures for the cultivation of rice construction of dikes in low-lying areas; establishment of necessary infrastructure for improved rice irrigation; and creation of agro-ecological research programs focused on integrated pest management and disease control.

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[13]Suriname. Second National Communication to the United Nations Framework Convention on Climate Change, February 2013, Publication of the Ministry of Labour, Technological Development and Environment. Paramaribo, Suriname.

Table 7.8 Resource system and resource unit factors identified in the interviews and documents' analysis.

Variable	N responses (interviews and documents)
Resource system	
RS4 Water infrastructure	
RS4a Deteriorated/insufficient infrastructure	11
RS5 Water scarcity	
RS5a Drought periods	1
RS8 Storage capacity	
RS8a Insufficient storage capacity	4
RS8b Millers storage overcapacity	2
Resource Units	
RU4 Economic value	
RU4a Output uncertainty	3
RU4b Water non-priced	3
RU7 Spatial and temporal distribution	
RU7a Seasonal variation	6

It is worth noting that after independence, some of the water infrastructure was left unfinished and the subsequent governments did not follow-up on the construction tasks, despite the fact that various consultancies have detailed the projects that should be needed (see Mertens, 2008 and HTSPE, 2009). This has reduced the operation capacity of some key elements of infrastructure, which has created water shortages in some crucial moments of the season. This is one of the main reasons why the sown area has been halved during the last decade. According to a farmer "there is no storage capacity, so you can use water in the rainy season and distribute to others". In addition, a water manager recognizes that "we have to spill a lot of water to avoid damage to the dam. But, maybe, one month later the swamp (supplying water for irrigation) gets to a minimum and we need to pump water into it".

The lack of proper water infrastructure is also related to the monitoring problems highlighted in the previous observation. The lack of infrastructure to divide the flows of different sections prevents managers from controlling water use and creates an additional problem by supplying water even if farmers do not need to irrigate their fields. As mentioned by a water manager "now you get water either you need it or not".

Millers' overcapacity to store grains is mentioned in two of the documents reviewed and relates to the reduction in rice quality as millers need to buy as much rice as they can regardless rice quality. The reduction in quality presses prices down, entering a vicious cycle of low competitiveness.

Furthermore, after independence, the research program in rice and the collection of hydrological and topographical data were reduced, having an impact on rice quality and production. For example, the most recent annual report of water resources in Suriname, which is a competence of the Ministry of Public Works, dates back to the 1988. It is also interesting to mention that with independence The Netherlands granted Suriname an aid package worth about 1.96 billion US$. However, after five years the government of Suriname had only spent 280,000 US$ (Singh, 2008), showing the difficulties of new-born countries to allocate budget and establish policy priorities. The lack of water information due to the difficult to metering worsens water security problems. In many cases, farmers need to take production decisions with very uncertain water supply.

Uncertain water supply also relates to uncertainty in harvest and, therefore, to the production value of output. This is to some extent related to the governance system characteristics, in addition to poor infrastructure development. Another related issue mentioned by interviewees is the low level of information sharing between farmers and government organizations and between research and government organizations. In this respect, information asymmetries might create inefficiencies in water distribution and be a means for power asymmetries in water access.

Also related to the economic value of water resources is the fact that water is provided free of any charge or levy, both the resource itself and the water distribution and drainage services. Three of the interviewees recognize that water is a highly political issue and, therefore, water pricing has remained dormant in the political agenda. Thus, water resources function primarily as an open access resource with very few rules determining appropriation and maintenance provision of waterways.

Regarding the spatial and temporal distribution, five interviewees highlight the seasonal variation in water availability. New rice varieties allow farmers to obtain two crops per year. However, one of the cropping seasons coincides with the dry season and, therefore, water for irrigation is essential.

The characteristics of the resource system and resource units favor an individual management of the resource. In particular, the lack of uncertainty in water supply due to poor water infrastructure, combined with an open access regime to the resource, facilitates individual action and makes cooperation more costly.

7.5.4 Users' characteristics

Observation 4. *Economic and social capital deterioration and insufficient farmers' organizational skills add complexity to the development of collective irrigation institutions.*

Table 7.9 reflects the users', in this case farmers, characteristics that may hinder collective action in irrigation. One of the aspects highlighted is the high level of

indebtedness of many farmers, which is somehow related to the macroeconomic crisis and land tenure problems. In this sense, farmers' indebtedness holds back investments in the irrigation sector. In addition, according to Poerschke (2005), there are strong motivational problems as farmers have assumed an attitude to wait for the government to set up good functioning irrigation and drainage systems. As a matter of fact, four interviewees recognized that farmers consider water provision to be a government's responsibility. Thus, changing farmers' mental models might be challenging in the short and medium term.

Two additional factors directly contribute to the existing water allocation problem: the rise of part-time farming and the land fragmentation with some farmers renting small or medium-size plots in many different places. Two interviewees highlighted the fragmentation of the land as an increasing number of farmers are part-time farmers and full-time farmers rent plots of land in different polders in order to reach a minimum economically feasible size for agriculture production. Part-time farming also relates to a lower dependency of livelihoods on agriculture. In this sense, larger dependency on the resource has been associated with higher probability of collective action.

Table 7.9 Users' characteristics identified in the interviews and documents' analysis.

Variable	N responses (interviews and documents)
U2 Socioeconomic attributes	
U2a Indebtedness problem	4
U3 History of irrigation	
U3a Farmers expect the government to provide water	5
U4 Location	
U4a Spread (rent in different polders)	4
U6 Norms / social capital	
U6a Lack trust in government / extension officers	3
U6b Social control disappeared	1
U6c Lack of trust in collective action performance	1
U7 Knowledge of irrigation	
U7a Lack of organizational/finance skills	7
U8 Dependence on the resource	
U8a More part time farmers	6
U9 Technology used	
U9a Old machinery park	3

The capacity of users to organize also depends on social capital factors and previous collective action experiences. In this sense, it is interesting to point out the failure of previous organization experiences along the rice market chain, which introduced an atmosphere of distrust that might be difficult to reverse. Overall, farmers' organizations have been an instrument of political parties to obtain support. Social norms are at the heart of social capital development. In this sense, political transitions have also influence the norms guiding social behavior. As recognized by

an interviewee: "social control disappeared. Our present society is very different to the 1960s"'.

A government official mentioned the generalized lack of trust that farmers have in both the government and agricultural extension officers. Thus, for example, "rice yields are higher than official figures. Farmers have the idea that if they declare higher yields they would need to pay more taxes". Therefore, any government initiative oriented towards the development of new irrigation institutions would require showing first the advantages, as mentioned by a local consultant "farmers would accept WB, but they would need to see the benefits".

Finally, a highlighted aspect in five interviews and in two of the documents is the lack of farmers' organizational and financial understanding. Thus, current investment programs place a large emphasis in capacity building as a mean to engage farmers in collective irrigation activities with positive financial outcomes.

The results presented so far show the relevance of both internal and external factors in the creation of the required social capital for collective action. In addition to users' characteristics, the political processes prevented social capital creation, undermining the viability of common-property arrangements.

7.6   Conclusions

The case of Suriname illustrates the multiple interrelations involved in the failure of collective action in the irrigation and drainage sector. An interesting feature of Suriname, compared to other case studies, is the transition from a colonial to a post-colonial status. The colonial period left an institutional legacy that included WBs and a strong colonial support to the agriculture sector all along the production and market chain. However, the post-colonial period was characterized by macroeconomic problems and political instability, which weakened the governance system and the households' economy. Market crises have affected the rice sector by pressing down the prices, reducing its profitability and compromising farmers' investment capacity.

In addition, demographic trends and the presence of attractive labor options outside agriculture make labor supply scarcer, with marginal wages from agriculture below the ones derived from other sectors as mining. This is also related to the increase in part-time farming and, therefore, to the reduction of livelihoods' dependence on agriculture and irrigation. Notably, dependence on the resource has been pointed out in the literature as a key factor influencing self-organization (Ostrom, 1990; Poteete *et al.*, 2010). Migration flows to The Netherlands after independence contribute to the country depopulation and, also, to some of the land tenure problems reported in the results.

Settlement patterns respond mainly to ethnic differences and have been inherited from the colonial period. Most irrigated agriculture is in the hands of people from a

Hindustani origin settled in the Nickerie district. According to Shah (2009), since 1830 the Indian model of irrigation development has mainly relied on the State for the design, planning and management of irrigation systems. In this respect, irrigation development in Suriname might reproduce some of the features of Indian irrigation institutions, where the State had most competencies and managed the projects with officers with very little participation and none financial contribution of the growers.

The results show that the lack of clear operational and collective choice rules creates an institutional vacuum in which rule breaking takes place with impunity. These governance characteristics also appear to be rooted in deeper political processes that date back to the colonial period and extend up to the present days. Even if strong rules, infrastructure and leadership are at the origin of the remarkable development of agriculture in a remote and sparsely populated country, a change of government and sovereignty can undermine the strongest foundations. Furthermore, the Dutch model of WBs, as extremely resilient, democratic and participatory institutions, served the purpose of protecting the land against floods in depressed territories, but in Suriname WBs struggle to operate independently because the problems and risks that farmers and irrigation districts face are different. While in Dutch WBs institutional failure can be catastrophic, in irrigation and drainage WBs' failure implies a slower process of decay and of building inefficiencies.

Overall, the results suggest that the social-ecological system developed during the transition process favored the emergence of opportunistic behavior, as the expected costs from cooperation were likely to surpass the expected benefits. In this respect, any attempt to revitalize WBs and support self-organization will need to consider broader social, economic and political factors, in addition to the investments in physical infrastructure and in hydrological information systems. Our empirical findings suggest that it is necessary to overcome the problems derived from ethnic heterogeneity, including land allocation, and government distrust in order to develop the social capital required for a collective action with equitable and economic efficient outcomes. Additionally, interaction with other related ecosystems, as a result of saline intrusion and climate change effects in the long-term need to be taken into account.

8   Main Conclusions of the Thesis

The research conducted in this thesis has been mainly motivated by the challenges that water reforms pose in developing countries. Inspired by the principles of integrated water resources management, recent water reforms in developing countries take place along deeper institutional and even constitutional changes. A wealth of scientific and *grey* literature suggests that institutional frameworks that might result in positive outcomes in countries governed by the rule of law might not fit in contexts governed mainly by informal or immature institutions.

This thesis has taken water reforms as the starting point, aiming to contribute to the literature by presenting several conceptual and empirical analyses at both general and individual levels, with reference to two very different countries. At the general national level, the focus is on the factors explaining failure of collective action in two different settings: 1) the implementation of the new Nicaraguan Water Law and 2) sustaining and revitalization of irrigation institutions in Suriname. At the individual level, the research focuses on resource users and analyzes the critical role of social variables for CPRs management.

The following sections outline the main theoretical, methodological and empirical insights derived from the thesis.

8.1   Water institutional reforms

Most scholar works analyzing policy implementation have been focused on contextual situations typical of developed countries. In chapter 4 of this thesis, I rely on various implementation theories to assess the implementation of the new Nicaraguan Water Law. The Social-Ecological Systems (SES) approach adopted in the study shows that there is an intimate link between the way legislative documents are drafted and worded and the context in which they are enacted. Some of the major barriers for the implementation of the new Nicaraguan Water Law have its reflection on the language of the Law and, therefore, on the way considered institutions are defined and configured. In this sense, our study shows that implementation cannot fruitfully be studied and understood without taking into account both the policy design and the social-ecological context in which it is framed.

From a methodological perspective, the institutional grammar and the analysis of interviews along the SES frameworks provide a promising toolkit for analyzing the roots of failing or successful policy implementation. The SES framework offers a potentially insightful approach to implementation studies because not only action situations can be studied at different scales, but also it can provide a more integrated view of the interactions between the governance system, users and the ecological system. In this respect, it can be a useful tool for diagnosing institutional changes and identifying potential bottlenecks along the policy process.

The application of the institutional grammar to the Nicaraguan Water Law reflects the centralization of decision-making power in a few government organizations without almost any enforcement mechanisms. Thus, most institutional statements included in the Water Law take the form of strategies and, therefore, only define to whom the institutional statement applies, the action contained in the statement and under which circumstances the statement is appropriate for application. However, strategies lack any prescriptive elements, which may open a gap between the spirit and intention of the legislator and the reality that the Law attempts to transform. This gap is susceptible to be occupied by all sorts of political entrepreneurs, grass root organizations and by a body of public officers that are neither supervised nor hold upward or downward accountable.

The Nicaraguan case shows some of the typical problems associated to institutional changes in the realm of natural resources policies. Considering that policy changes are likely to reshape power configuration, the specific setting of Nicaragua highlights the role of both formal and informal institutions when promoting policy transitions. This is particularly relevant in countries in which external actors, as development agencies, have actively promoted "the rule of law". Despite the fact that water reforms implementation needs long periods of time, the gap between rules on paper and rules on the ground deserves further attention when proposing policy changes that rely on formal institutions. A better understanding of the interplay between informal and formal institutions would contribute to better tailor institutions to the actual context.

An important limitation of the study in chapter 4 is the lack of a comparative perspective. In this respect, a relevant avenue for further research would be looking at different water reforms across countries. A larger sample of countries would, in the vein of Saleth and Dinar (2004), enhance our understanding about the factors that interact within the social-ecological system and hinder water reforms implementation and how these factors could be overcome. Another essential area of research is assessing what institutions devised in water laws and policies display better outcomes considering context-specific characteristics. For this purpose, the institutional grammar tool might be further developed to understand the key roles of prescription elements in the policy documents.

8.2 Social capital and irrigation

Social capital factors have been highlighted as central for collective action in the commons. Chapter 5 delves into the relation between social capital dimensions, the participation at community level and its reflection in irrigation organizations. The study adopts a two-stage econometric approach to analyze the influence of social capital in collective irrigation. In this respect, it allows us to take into account self-selection problems in collective irrigation and, therefore, disentangle the relations between social capital and participation in collective management. Furthermore, in regard to social capital variables, structural and cognitive factors are distinguished,

showing the relevance of cognitive variables in explaining collective action at community level. Most studies include "participation in organizations" as an indicator of social capital. However, participation might respond more to the individual benefits obtained from participation than to a sense of community or social interests. Thus, for example, participation in cooperatives might be better explained by the access to credit or cheaper inputs and not necessarily reflect trust relations or some other type of social capital.

The results presented in chapter 5 suggest that the inclination to cooperate is related to past collective action experiences. As pointed out in Ostrom (1990), self-organization is a learning process and therefore past experiences might determine expected future outcomes from cooperation and influence individuals' decisions. The empirical findings also provide evidence on the inverse U-shaped relation between collective action and the level of household assets. This signifies that households at both extremes of the distribution in terms of assets are less prone to participate in collective initiatives. This finding should be taken into account when government agencies attempt to form groups of farmers to engage in any type of collective action. The poorest may be reluctant or too impaired to engage in collective projects, requiring more basic support. Thus, incentives for collective action need to be devised and tailored to the specific economic context.

The results also support the argument that collective action is very often catalyzed by external shocks which put the system under stress, requiring the search of collective solutions that enable users to deal with the disturbances. In addition, despite the relevance of property rights, the results show that secure land tenure is not a sufficient condition for participating in collective irrigation systems.

An interesting result from the study is the negative relation between participation in community meetings and participation in collective irrigation systems, which mainly rely on family ties. In this respect, family ties might serve as the basis for establishing formal irrigation institutions in countries in which the blood ties play a central social role. However, benefiting from collective action might require the establishment and use of networks outside the family, which mainly rely on bridging and linking social capital with other type of organizations.

This study falls short in explaining the process of social capital creation, which puzzles many research specialists in economic development. A qualitative perspective would help in better understanding the development of collective irrigation systems and the nexus between social capital and collective irrigation. Another area for further research remains in the study of the impact of collective vs. individual irrigation in the economics of the household and under which circumstances the net benefits from cooperation surpass the net benefits of individual action.

8.3 Collective action in the commons through the lens of a field experiment

The aims of the research reported in chapter 6 reflect the type of social dilemmas found in irrigation organizations. Experimental analysis affords a vivid inquire of the behavior of students and villagers in Nicaragua when confronted with these decisions. The results reveal that students and villagers display different outcomes in similar contextual definitions in the course of the games, with villagers allocating more units of effort to common pool resource (CPR) appropriation than students, which, in turn, affects CPR availability and determines the efficiency of the game.

The fact that appropriation and contribution are positively correlated indicates a correspondence in decisions: this is a situation in which a lot is taken from CPR and a lot is expended in restoring it to avoid depletion. This has considerable efficiency losses and consolidates a collective path for which there is no easy exit. As the marginal benefits from appropriation are above the marginal increase in CPR from public good provision, a vicious cycle of inefficiency is created, in which the villagers are more likely to fall than students. Our research does not hint at potential underlying reasons explaining the behavioral differences of villages and students.

Chapter 6 shows that information disclosure of other agents' behavior increases the likelihood of CPR depletion as this enables resource users to adapt their appropriation and provision strategies in light of the information they receive on others' appropriation behavior. Although information is usually presented as a mechanism for enhancing cooperation, the results presented in this chapter also suggest that information might have counterproductive outcomes in terms of resource use. Unfortunately, the data do not allow us to identify the specific mechanisms through which information disclosure might restrain appropriation and provision decisions. A candidate explanation might be that information disclosure enables participants to punish their peers at an individual cost when gains distribution is inequitable. In our game, altruistic punishment could be interpreted in the sense that some individuals decide to reduce both appropriation and public good provision levels, with public good provision reduction being larger than the appropriation one. By reducing the level of public good individuals compromise both social and individual future gains. Information disclosure on peers' behavior could also influence risk preferences, with more individuals behaving in a risk adverse manner. The fact that people accumulate their endowment, reducing participation in the game, might indicate a preference for secure assets compared to somehow uncertain outcomes from the dynamic game. Understanding the factors that explain the differences in behavior once information on players' decisions is displayed would deserved further exploration in future research.

From a methodological point of view, the research reported in chapter 6 combines a public good and a common pool resource game in a dynamic context. This novel experiment provides a richer setting for analyzing cooperation in the commons.

However, due to the multiple game equilibria, results are more difficult to analyze in light of the theory, being this one of the serious limitations of the study.

An interesting insight from the analysis conducted in chapter 6 is the impact of group composition, in terms of sex composition, in game outcomes. Although the data do not allow me to establish conclusions from a gender theoretical perspective, the fact is that sex composition significantly matters for the game outcomes. A further consideration of gender might be relevant for future research in the commons. Thus, for example, the results suggest the importance of group composition in terms of cooperation, fairness and altruism norms, which might also have its reflection on the gender relations.

Future work could focus more on exploring the role of ecological dynamics in game decisions. It would be interesting to analyze how uncertainty and shocks in CPR availability affect appropriation and provision strategies under different institutions.

In line with previous studies (Janssen *et al.*, 2011, 2012), the results show that player's position matters, in particular, for CPR appropriation. In this respect, promotion of self-organization would need to take into account *de facto* or built in existing power asymmetries. In an asymmetric context, due to differences in position, access or resources, overcoming irrigation dilemmas might be more complicated than in symmetric situations. In chapter 6, asymmetry is introduced in players' position and determines when an individual is able to access the CPR, all else being equal. This setting is commonly found in large irrigation schemes where those at located head have the right to be the first in appropriating the resource and those at the tail are last. In this sense, another interesting line of research would be to analyze the effect of asymmetry in individual's endowment. The initial endowment determines the capacity of participants to appropriate CPR units. In addition, chapter 6 explores the effect of pro-social preference on game outcomes. An interesting perspective would be to analyze the effect of game outcomes in shaping pro-social preferences. This type of approach would provide new insights into the external validity of the experiments.

8.4 Deconstruction and revitalization of collective irrigation

In sharp contrast with the case of Nicaragua, chapter 7 analyzes the process of deconstruction of collective irrigation in Suriname and the current revitalization attempts based on the irrigation and drainage institutions mostly developed during the colonial period. The case of Suriname provides a rich setting for the analysis of collective action in transition economies. In addition to the typical internal factors explaining failure of collective action, the Surinamese case highlights the relevance of political changes in shaping the (dis)incentives for collective action.

From a theoretical perspective, this study deepens the understanding of water governance systems in the face of political and institutional transitions. The results

highlight the relevance of the macroinstitutional structure in determining the perceived costs and benefits of cooperation at the micro level. The methodological approach adopted in chapter 7 allows us to organize the empirical data from a broader social-ecological perspective. The framework identifies the key variables that have been associated in the academic literature to self-organization and provides the theoretical underpinning for explaining failure of collective action in irrigation and drainage systems in Suriname. This approach allows us to understand institutional change from a multi-tier perspective, acknowledging the interrelations between human and nature systems.

A relevant observation from the study is that most of the variables frequently associated with collective action in the commons were also highlighted in relation to the failure of collective irrigation in Suriname. From a theoretical perspective, the Surinamese case suggests the relevance of considering collective action and self-organization as separate processes. Although self-organization implies collective action, the fact that people act collectively does not necessarily imply self-organization. As a matter of fact, collective irrigation and drainage in Suriname has always relied on external (colonial state-crafted) rules and support.

The empirical data gathered through interviews and existing reports shows that the post-colonial state inherited a large government apparatus (including the military), but lacked the robustness for it to be efficient in managing the delicate balance of large irrigation schemes that service water and manage drainage of rice paddies. Current initiatives for revitalizing collective irrigation institutions struggle with a very fuzzy and transitional water governance system. In this sense, the current attempts for devolving water management to WBs do not fall on a fertile ground where self-organization can easily flourish. On the contrary, decades of decay, mistrust in government, and demise of institutions that were set up during the colonial times, inspired on the institutional set up of Dutch Water Boards, have contributed to erode the basis on which the revitalization policy is meant to rest. This is essence the major difficulty that the Surinamese government must overcome.

The main policy conclusion of this chapter is the role, or lack thereof, of leadership at the highest political level to steer a policy reform that wisely takes the foundations of the WBs as a founding element. When growers and officers have lived decades of decay, a strict bottom-up approach is insufficient, especially in the case of irrigation organizations that supply water and manage drainage of rice paddies. The role of government is essential, a fact that suggests that there is still a long way for the Surinamese Government to achieve. However, leadership needs to be built on a legitimate basis, for which shared clear rules at the constitutional, collective and operational level are needed.

A policy-relevant recommendation that stems from the analysis in chapter 7 is that revitalization of existing WBs will need to focus, at least, on the following three key

elements: 1) the infrastructure system, adapting the physical needs to the current environment (i.e. considering climate change patterns and saline intrusion dynamics), as on; 2) the governance system, with particular emphasis on the definition of the coordination mechanisms among the different organizations involved in water resources management and on the participation of users in the design of operational rules and 3) the users, by developing further their financial and managerial skills.

The study falls short in examining the link of macro and microsituational variables. In this respect, an interesting area of research remains in exploring the interactions between the broader social-ecological context and the microsituations. Another policy-relevant extension of the research includes revisiting the process of WBs revitalizations, in lieu of the revised policies approved by the Surinamese Government as a result of the IDB policy loans. In this respect, it would be interesting to study how the bottom-up and top-down approaches work in this renewed attempt to revitalize collective irrigation and drainage in Suriname.

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Appendix

Appendix 1. Coding examples

Institutional Grammar Tool. Coding example using HyperRESEARCH 2.8.3
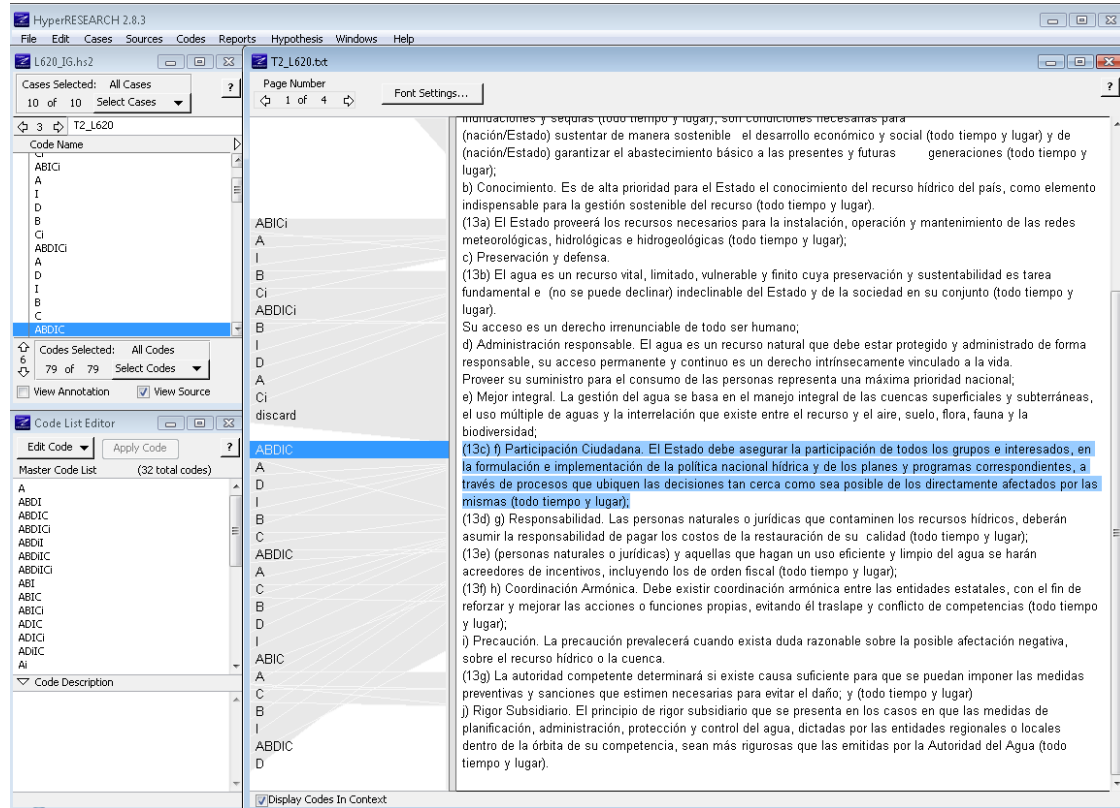
Interview's coding based on the SES variables. Coding example using HyperRESEARCH 2.8.3
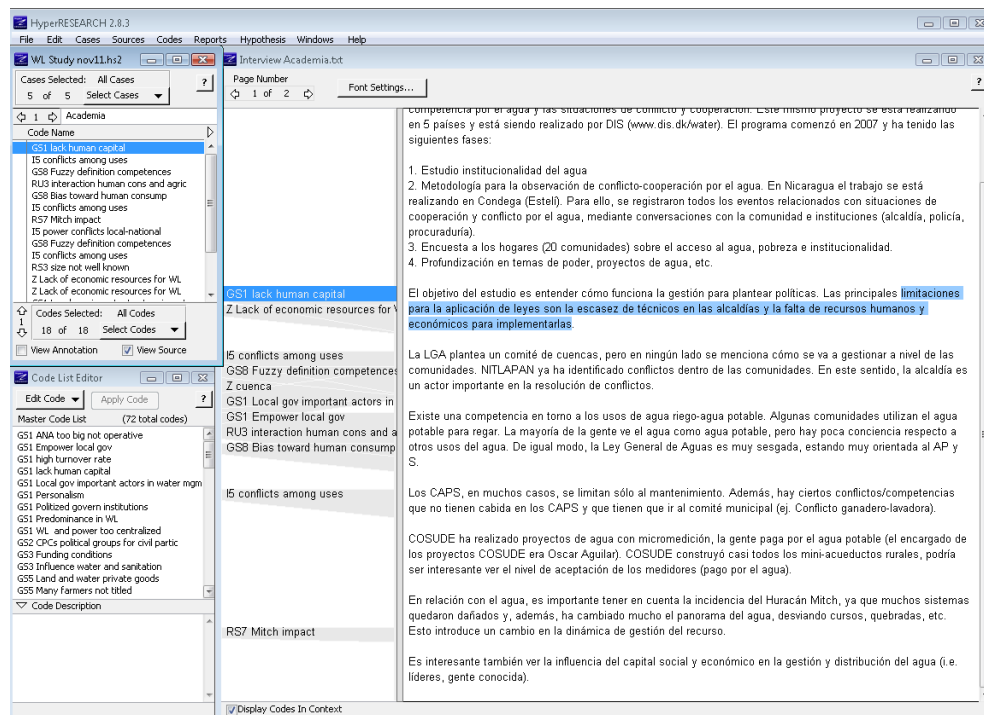
Appendix 2. Survey on agricultural production and social capital

ENCUESTA SOCIOECONÓMICA Y DE CAPITAL SOCIAL EN LA SUB-CUENCA ALTA DEL RIO VIEJO

Nombre del entrevistador: Fecha de la entrevista:

Nombre del entrevistado: Número de cédula: Sexo: M 01 / F 02

Número de encuesta:

Parte 1. Información general y datos estratégicos TERRENA

1. Localización de la vivienda
    1.1. Comunidad   1.2. Municipio

2. ¿Cuántas personas residen habitualmente en la vivienda? (Indicar número)

3. Se considera que una familia está formado por una persona o conjunto de personas, parientes o no, que se mantienen de un gasto común para comer, ¿Cuántas familias hay en la vivienda? (Indicar número)

4. ¿La familia es beneficiaria de alguno de los proyectos del Programa TERRENA? (marcar con una cruz donde corresponda)
    Si   [ ] 01   No   [ ] 02
4.1. ¿De cuál?

PMFS	[ ] 01	Fortalecimiento CAPS	[ ] 03	COLOPRED	[ ] 05	Ninguno	[ ] 07
Fondo/crédito	[ ] 02	CMC	[ ] 04	Escuela campo	[ ] 06	Otro	[ ] 08 ¿cuál?:

5. ¿Han recibido apoyo técnico, económico o de otro tipo de algún proyecto de desarrollo agropecuario en los últimos 5 años?
    Si   [ ] 01   No   [ ] 02 →**Ir a P6**
5.1. ¿Con qué instituciones?

MAG FOR	[ ] 01	Otra institución del gobierno	[ ] 03	Asociación gremial	[ ] 05	Ninguno	[ ] 07
INTA	[ ] 02	ONG	[ ] 04	Otra, ¿Cuál?	[ ] 06		

6. Quién es la persona de la familia. (Escribir nombre y parentesco con el/la cabeza de familia, según los códigos de la pregunta 27)
    6.1. Mejor informada sobre la actividad agropecuaria
    6.2. Que toma las decisiones sobre la producción

7. ¿Cuál es la principal fuente de ingreso de las familias que habitan en la vivienda? (marcar con una cruz)

Agricultura en la finca familiar	[ ] 01	Doméstico	[ ] 03	Sector público	[ ] 05	Otros	[ ] 07

Agricultura fuera de la finca familiar   [ ] 02   Sector privado   [ ] 04   Remesas   [ ] 06   ¿Principal? [ ]

Parte 2. Datos sobre la unidad de producción agropecuaria

8. En los últimos 12 meses, ¿trabajaron en tierras propias?   Sí [ ] 1 →8.a. ¿En cuántas fincas? [   ] →**Ir a P9**
No [ ] 2→**Ir a P30**

2.1. Fincas o parcelas propias: Información general de la finca

Número parcela	9. Registre en cada fila el uso principal que tienen las parcelas propias del hogar (*En Excel anotar 1-Si, 2-No según tengan o no el cultivo*)		10. ¿Siempre han cultivado los mismos lotes en la parcela? Si…..99 No…¿Cuál?		11. ¿Cuál es el tamaño / superficie de esta finca, parcela o predio?		12. ¿En qué comunidad está ubicada la finca?	13. ¿Cuál es la pendiente del terreno en la finca? <10%.....01 >10%.....02	14. ¿Qué tipo de terreno es?	15. ¿Tiene superficie bajo riego? Si….indicar abajo No... **Ir a P24**		16. ¿Qué tipo de cultivo riega en la finca?
	Nombre finca	Cód.	Uso anterior	Cód.	Superficie	Mz.	Comunidad	Cód.	Cód.	Superficie	Mz.	Cód.
1												
2												
3												
4												
5												
6												
7												

Códigos Preguntas 9, 10 y 16				**Códigos Pregunta 14**	
Caña de azúcar…	01	Tacotal o descanso…..	07	Pedregosidad >30% superficie….	01
Granos básico…...	02	Bosques……………..	08	Pedregosidad 15-30% superficie..	02
Hortalizas……….	03	Otro, ¿cuál?................	09	Pedregosidad <15% superficie….	03
Tabaco………….	04				
Algodón…………	05				
Pastos………….	06				

Continuación Parte 2.1. Fincas o parcelas propias: Información riego

Número parcela	17. ¿Qué meses de verano tiene disponibilidad de agua para el riego? (Indicar el periodo de meses de verano en los que tiene agua para riego)		18. ¿Cuál es la fuente de agua para el riego? (En una finca puede haber más de una fuente de agua para riego, anotar la principal) *En Excel anotar 1-Si 2-No según tengan la fuente de riego*	19. ¿Qué tipo de riego tiene en la finca? *En Excel anotar 1-Si 2-No según tengan el tipo de riego*		20. ¿Desde hace cuanto tiempo tiene este tipo de riego en la finca? (Indicar el número de años que tiene utilizando el sistema de la P19	21. ¿Comparte el sistema de riego con alguien? Si…...01 (completar nombre/nº/cod) No….02 →**Ir P24**		22. Los miembros que comparten el sistema de riego (presas, pozos o canales) son de la misma… **(respuesta múltiple)** (*En Excel 1-si 2-No*)	23. ¿Quién participa en las tareas de construcción y mantenimiento del sistema de riego? **(respuesta múltiple)** (*1-si 2-No*)
	Meses		Cód.	Superficie	Cód.	Años	Nombre / Nº	Cód.	Cód.	Cód.
1										
2										
3										
4										
5										
6										
7										

Códigos Pregunta 18		**Códigos Pregunta 19**		**Códigos Preg. 21**		**Códigos Pregunta 22**		**Códigos Pregunta 23**	
Presa en el rio………..	01	Gravedad + inundación…	01	Canal………...11		Familia………....	01	Propietarios……….……	01
Motor en el rio……….	02	Motor + inundación…….	02	Pozo…………12		Religión…………	02	Familiares no asalariados	02
Pozo excavado mano en la finca………..........	03	Gravedad + goteo……….	03	Otro, ¿cuál? ….13		Género………….	03	Familiares asalariados….	03
		Motor + goteo…………...	04	No comparte…02		Edad…………......	04	Jornaleros………………	04
Pozo excavado a mano fuera de la finca……...	04	Motor + aspersión……….	05			Partido político….	05	Otros, ¿Cuál?....................	05
Pozo artesiano en finca	05					Nivel educativo.....	06		
Pozo artesiano fuera finca…………...……	06					Comunidad……...	07		
						Medieros………....	08		
						Socios…………..	09		
						Amigos………….	10		

Continuación Parte 2.1. Fincas o parcelas propias: Información sobre el régimen de tenencia

Número parcela	24. ¿Cuántos años tiene de tener la finca en propiedad?	25. ¿Cómo adquirieron la finca?	26. ¿Qué documento de propiedad tienen? Si no tienen documento →**Ir a P29**	27. ¿A nombre de quien está la escritura de propiedad? Indicar el nombre de la persona que aparece en el documento legal y su relación con el/la cabeza de familia		28. ¿La propiedad está inscrita en el registro público? Si…..01 No…02	29. ¿De quién es la tierra?
	Núm. años	Cód.	Cód.	Nombre	Cód.	Cód.	Cód.
1							
2							
3							
4							
5							
6							
7							

Códigos Pregunta 25		Códigos Pregunta 26	
Compra…………………………………………………..	01	Escritura……………………………………….…	01
Herencia………………………………………………..	02	Título de reforma agraria…………………….	02
Adjudicada por reforma agraria individual………………	03	Carta/Promesa de venta………………………....	03
Adjudicada por reforma agraria en forma de cooperativa.	04	Documento de asignación……………………..	04
Invasión / Ocupación……………………………………	05	Título de posesión y mejora…………………..	05
Regalada / Cedida………………………………………	06	La tiene la directiva, otra persona o institución	06
Otro, ¿Cuál?...	07	Sin documento………………………………….	07

Códigos Pregunta 27						Códigos Pregunta 29	
Cabeza…………….	01	Nieto/a……	08	Primo/a………………	15	Tierra estatal……….	01
Esposo/a…………..	02	Abuelo/a….	09	Otro/a familiar……...	16	Tierra comunal……..	02
Hijo/a……………..	03	Suegro/a….	10	Otros no familiares….	17	Una cooperativa……	03
Padre/madre………	04	Yerno/nuera	11			Tierra familiar……...	04
Hermano/a………..	05	Cuñado/a…	12			Tierra particular……	05
Hermanastro/a…….	06	Sobrino/a…	13			Otro, ¿Cuál?.............	06
Padrastro/madrastra.	07	Tío/a……..	14				

Continuación Parte 2.1. Información sobre la comercialización y los problemas agropecuarios

30. ¿Existe en la comunidad algún centro de acopio o canales para comercializar la producción agrícola? (marcar con una cruz donde corresponda)
Sí, centro de acopio [ ] 01 Sí, ambos [ ] 03 Ninguno[ ] 05**Ir a P31***En Excel anotar Sí-01, No-02*

Sí, canal de comercialización [ ] 02 Otro, ¿Cuál? [ ] 04

30a. ¿Utiliza el centro de acopio/canal de comercialización de la comunidad? Sí [ ] 01 No [ ] 02 Si la respuesta es no indicar ¿Por qué?

31. ¿Cuál es la principal vía de acceso en todo tiempo para sacar la producción agrícola a los puntos de venta? (marcar con una cruz donde corresponda)
Carretera / calle pavimentada o adoquinada [ ] 01 Camino / calle de tierra de verano [ ] 03 Trocha de verano [ ] 05
Camino / calle de tierra de todo tiempo [ ] 02 Trocha de todo tiempo [ ] 04 Otro, ¿Cuál? [ ] 06

32. La mayor parte de su producción agrícola la vende: (marcar con una cruz donde corresponda) – *En el Excel Sí-01 / No-02*
Directo al consumidor [ ] 01 Comerciante de afuera [ ] 03 Cooperativa [ ] 05 No venden**Ir a P36**[ ] 07
Comerciante del municipio [ ] 02 Organización de productores [ ] 04 Otro, ¿Cuál? [ ] 06

33. ¿La venta de su producción agrícola la realizan fuera de la finca? (marcar con una cruz donde corresponda)
Sí [ ] 01 No [ ] 02**Ir a P36**

34. ¿Qué medio de transporte usan frecuentemente para sacar su producción de la finca al lugar de venta? (marcar con una cruz)
Animal de carga [ ] 01 Bus [ ] 04
Carreta con bueyes / caballos [ ] 02 Otro, ¿Cuál? [ ] 05
Camión / camioneta [ ] 03 Si anoto varias, ¿Qué medio utiliza más? [ ] (Anotar código)

35. ¿Cuánto tiempo se demora en llegar de su finca al lugar de venta y a qué distancia se encuentra?
Tiempo [ ] minutos 01 [ ] horas 02
Distancia [ ] varas 01 [ ] metros 02 [ ] km 03

36. ¿En el último año ha visto afectada su actividad agraria por alguna de las siguientes situaciones? (respuesta múltiple, marcar con una cruz)
Sequía [ ] 01 Invasión de tierras [ ] 04 Si anotó varias, ¿Cuál le afecto más? [ ] (Anotar código)
Plagas / enfermedades [ ] 02 Robo [ ] 05
Inundaciones [ ] 03 Violencia física [ ] 06

37. ¿Qué hicieron en estos casos? (respuesta múltiple, marcar con una cruz donde corresponda)

Recibió préstamos por los que no pagó intereses	[ ] 01	Gastó sus ahorros financieros [ ] 07	Sembraron otros
Recibió préstamos por los que tuvo que pagar intereses	[ ] 02	Recibió apoyo de algún ONG [ ] 08	productos [ ] 13
Dejó de cancelar deudas	[ ] 03	Recibió apoyo del gobierno [ ] 09	Nada [ ]14
Reestructuró la deuda con las entidades financieras	[ ] 04	Recibió apoyo de la alcaldía [ ] 10	Si anotó varias,
Vendió activos, bienes, propiedades o animales, que no hubiera vendido en otro caso	[ ] 05	Aumentó sus horas de trabajo [ ] 11	¿Cuál fue la más
Recibió ayuda en efectivo o en especies, de parientes o vecinos	[ ] 06	Redujo el consumo familiar [ ] 12	importante? [ ]

38. ¿En el último año cuáles fueron los 3 principales problemas que tuvo para comercializar sus productos? (Respuesta múltiple, anote en los recuadros en orden de importancia)

1	2	3

Precios de venta muy bajos…………………… 01   Lugar de venta está muy lejos………………… 05   Poca demanda………………… 09

Intermediarios cobran comisiones muy altas…. 02   Carretera en mal estado……………………… 06   Pertenece a una cooperativa….. 10
Precios de transporte muy altos……………… 03   No existe carretera…………………………… 07   No comercializa……………….. 11
Falta de transportistas en la zona……………... 04   Falta seguridad……………………….…… 08   Otro, ¿Cuál?.............................. 12
                                                                                                    Ninguno……………………… 13

39. ¿Durante el último año qué otros problemas afectaron principalmente a su producción?(Respuesta múltiple, anote en los recuadros en orden de importancia)

1	2	3

Precios altos de los insumos agrícolas………... 01   Falta de financiamiento………   04   Regulación o intervención excesiva del gobierno…   07

Precios altos de la mano de obra……………... 02   Competencia excesiva………   05   No tiene tierras propias……………………………   08
Falta de capital propio………………………... 03   No le pagan a tiempo los clientes   06Otro, ¿Cuál?..   09
                                                                                            Ninguno………………………………………..   13

Parte 3. Información sobre el capital social

Numero	40. Indique los nombres de las personas que residen habitualmente en la vivienda (Escriba primero el cabeza de familia, indique solo los nombres)	41.¿Cuál es la relación de…..con el/la cabeza de familia?	42. Sexo Varón….01 Hembra..02	43. Nivel educativo	44.¿Cuántos años tiene…?	45. ¿Cuánto tiempo lleva viviendo… en la comunidad?	46. Ocupación (Actividad a la que dedica más horas)	47. En esta ocupación (la señalada en 46) …. trabaja como
	Nombre	Cód.	Sexo	Cód.	Edad (años)	Años	Cód.	Cód.
01								
02								
03								
04								
05								
06								
07								

Códigos Pregunta 41

Cabeza…………….	01	Nieto/a……	08	Primo/a………………	15
Esposo/a…………..	02	Abuelo/a….	09	Otro/a familiar……....	16
Hijo/a……………..	03	Suegro/a….	10	Otros no familiares….	17
Padre/madre………	04	Yerno/nuera	11		
Hermano/a………....	05	Cuñado/a…	12		
Hermanastro/a…….	06	Sobrino/a…	13		
Padrastro/madrastra.	07	Tío/a……...	14		

Códigos Pregunta 43

Alfabetizado, sin escolaridad	01	Universitario/a...	08
Sin alfabetizar, sin escolaridad	02	Otros…………..	09
Primaria incompleta…………	03		
Primaria completa……………	04		
Secundaria incompleta………	05		
Secundaria completa…………	06		
Técnico/a……………………	07		

Códigos Pregunta 46

Agricultura en la finca familiar……….	01
Agricultura fuera de la finca familiar…	02
Domestico……………………………...	03
Sector privado…………………………	04
Sector público…………………………	05
Remesas………………………………..	06
Estudios………………………………..	07
Otros, ¿Cuál?..………………………...	08

Códigos Pregunta 47

Empleado/obrero…………..	01
Cuenta propia……………...	02
Trabajador sin pago………..	03
Jornalero/peón……………..	04
Miembro cooperativo……...	05
Patrón/empresario…………	06
Otros, ¿Cuál?………………	07

3.1. Medidas del capital social estructural

- Las preguntas de esta sección recogen información sobre la valoración de la comunidad/municipalidad y la forma en la que los entrevistados participan en las actividades de la comunidad/municipalidad.

3.1.1. Características y densidad de las organizaciones

48. ¿Usted o alguien en el hogar es miembro de algún grupo, organización o asociación? De ser así, ¿se considera usted o a la persona del hogar un miembro activo en el grupo, participando en las reuniones, talleres, directiva, etc.?

Miembro del hogar (usar número de persona definido en Parte 3)	Nombre de la organización 48a	Tipo de organización (usar códigos) 48b	Grado de participación (usar códigos) 48c

Tipo de organización – 48b				Grado de participación – 48c	
Grupo agricultores	01	Grupo político	12	Líder	01
Cooperativa	02	Asociación cultural	13	Muy activo	02
Asociación comerciantes	03	Asociación juvenil	14	Algo activo	03
Asociación profesional	04	Asociación de mujeres	15	No activo	04
Asociación crédito	05	Comité de escuela	16	No aplica	22
CAPS	06	Comité de salud	17		
Comité Poder Ciudadano	07	COMUPRED	18		
Comité Desarrollo Local	08	Comité microcuencas	19		
Comité Desarrollo Municipal	09	CAS	20		
ONG	10	Otros, ¿Cuál?	21		
Grupo religioso	11	No aplica	22		

49. Dentro de las organizaciones que mencionó, ¿Cuál de estos grupos valora como más importante para su hogar? Nombrar los tres más importantes e indicar el nombre y el tipo de organización, según el código definido en la pregunta 48 (48b).

Grupo 1:   [   ]
Grupo 2:   [   ]
Grupo 3:   [   ]

50. ¿Los miembros de los grupos (de los tres más importantes para el entrevistado) son…?

Indicar 01- 02 según corresponda Si 01 No aplica 03 No 02	Grupo 1	Grupo 2	Grupo 3
De la misma familia?			
De la misma religión?			
Del mismo género?			
De la misma edad?			
Del mismo partido político?			
Del mismo nivel educativo?			
De la misma comunidad?			

51. ¿Cómo se toman normalmente las decisiones dentro de estos tres grupos que considera los más importantes? Indicar el código que corresponda

Grupo 1	Grupo 2	Grupo 3

El líder/junta directiva decide e informa al resto de los miembros   01
El líder/junta directiva pregunta a los miembros del grupo que piensan y luego decide   02
Los miembros del grupo discuten sobre lo que piensan y deciden juntos   03
Otros (especificar)   04
No aplica   05

3.1.2. Networks

52. Si hubiera un problema que afectara a toda la comunidad, por ejemplo, una peste que afecte a todos los cultivos de la comunidad, ¿Quién cree que se juntaría para tratar de buscar una solución al problema? (marcar con una cruz donde corresponda)

	Sí	No
Cada persona/familia actuaría de manera individual	01	02
Los vecinos entre ellos	01	02
Los líderes políticos de cada partido se juntarían para apoyar a los miembros de su partido	01	02
Todos los líderes de la comunidad actuarían de manera conjunta	01	02
Toda la comunidad se juntaría	01	02
Los socios pedirían ayuda a la cooperativa	01	02
Otros (especificar)	01	02

53. ¿Quién cree que tomaría la iniciativa y actuaría como líder? (Nombre 53a / características relevantes de la persona 53b)

3.1.3. Acción colectiva previa

54. ¿Durante el último año con qué frecuencia los miembros de la comunidad se han juntado para solicitar proyectos de desarrollo de la comunidad a los miembros del gobierno o líderes políticos? (marcar con una cruz donde corresponda)

Nunca		01	**Ir a la 56**
Una vez		02	
Un par de veces		03	
Frecuentemente		04	

55. ¿Alguna de estas acciones tuvo éxito? (marcar con una cruz donde corresponda)

Sí, todas tuvieron éxito   [ ] 01   Algunas tuvieron éxito   [ ] 02   Ninguna tuvo éxito   [ ] 03

56. En conjunto, ¿Cómo valoraría el espíritu de participación que existe en esta comunidad? (marcar con una cruz donde corresponda)

Muy bajo		01
Bajo		02
Medio		03
Alto		04
Muy alto		05

57. ¿Cómo valoraría la contribución que usted puede hacer para que esta comunidad sea un lugar mejor para vivir? (marcar con un cruz)

Mucha		01
Alguna		02
No mucha		03
Ninguna		04

3.2. Medidas del capital social cognitivo

3.2.1. Solidaridad

58. Imagine que su vecino/a sufre una pérdida económica elevada, por ejemplo, que pierde la cosecha. En esta situación, ¿Quién cree que le ayudaría financieramente? (Anotar solo los tres primeros según los códigos de la tabla que aparece debajo)

A	B	C

Nadie ayudaría	01	Amigos	04	Jefe/empleador	07	Alcaldía	10	Otros, especificar	13
Familia	02	Grupo o líder religioso	05	Líder político	08	Gobierno	11		
Vecinos	03	Líder de la comunidad	06	Cooperativa	09	ONG	12		

3.2.2. Confianza y cooperación

59. ¿Usted cree que en general la gente de la comunidad tiene confianza en otros miembros de la propia comunidad para prestar o pedir prestada plata? (marcar con una cruz donde corresponda)

Confía [ ] 01
No confía [ ] 02

60. Imagine que alguien en la comunidad, junto con su familia, tiene que irse fuera por una temporada. ¿A cargo de quien podrían dejar sus fincas? (Apuntar los tres primeros, según el código de la tabla que aparece debajo)

A	B	C

Otro miembro de la familia	01	Vecino	02	Cualquier persona de la comunidad	03	Otro (especificar)	04	Nadie	05

61. Imagine que un amigo suyo en la comunidad tiene que decidir entre estas dos alternativas, ¿Cuál cree usted que escogería? (marcar con una cruz donde corresponda)

Tener una finca de 10 mz para el solo		01
Tener una finca de 25 mz compartida con otra persona y sin posibilidad de dividirla		02

3.2.3. Resolución de conflictos

62. En su opinión, ¿la gente de esta comunidad es generalmente tranquila o conflictiva? (marcar con una cruz donde corresponda)

Tranquila		01
Conflictiva		02

62a. En comparación con otras comunidades, ¿en esta comunidad hay más o menos conflictos por la tierra/agua?

Más		01
Los mismos		02
Menos		

63. ¿La gente de la comunidad contribuye con tiempo y dinero a los proyectos de desarrollo comunitarios?(marcar con una cruz donde corresponda)

Contribuyen algo o mucho		01
Contribuyen poco o nada		02

64. ¿Quién cree que podría ayudar a resolver una disputa si dos miembros de la comunidad tuvieran un problema por….(Indicar **DOS** códigos según la importancia. Utilizar la tabla que aparece debajo)

Las tierras (ej. Los límites de una finca)　　　[　　]　　　Uso del rio (ej. Uso lavar – uso riego)　　　[　　]
El agua de riego　　　　　　　　　　　　　　[　　]
El agua de tomar　　　　　　　　　　　　　　[　　]

Nadie, lo resolverían entre ellos/as	01	Líder de la comunidad	04	Alcaldía	07	MAG FOR	10	Otros, especificar	13

| Familia / miembros del hogar | 02 | Líder religioso | 05 | Procuraduría | 08 | INAFOR | 11 | Ninguno | 14 |
| Vecinos | 03 | Juzgado | 06 | MARENA | 09 | CAPS | 12 | | |

65. ¿Tienen conocimiento de algún conflicto en su zona por el uso del agua en los últimos tres años? (marcar con una cruz)

Agua vivienda	[ ] 01	Agua riego	[ ] 03	Acequias riego	[ ] 05	Ordenanza municipal	[ ] 07	Ninguno	[ ] 09
Agua ganado	[ ] 02	Represas río	[ ] 04	Derechos pasada	[ ] 06	Contaminación aguas	[ ] 08	Otros, ¿cuál?	[ ] 10

Appendix 3. Instructions for the irrigation game

Welcome to the irrigation game,

This game imitates the type of decisions that users of a collective irrigation system need to take. These instructions provide detailed information on the decisions a player can take and the consequences of these decisions. With your decisions, you can earn money that you will receive at the end of the game. During the game, we will not use Córdobas but points. The points you earn in the game will be converted into Córdobas at the end of the game (i.e. 1 point = 1 Córdoba[14]).

During the experiment, participants are not allowed to communicate among each other. If during the game, you have any question, please, raise your hand and some of the people facilitating this session will approach you and answer the question personally.

The game

In this game you are in a group with three other participants, that is, each group is composed by 4 people. The members of your group are the same for all the periods of the game. At the beginning of the game, your group receives an initial amount of common pool points and each player receives a personal endowment of **20 points**. After the first round, your endowment will be the payoffs from the previous round. Your decisions in the game can affect this common pool. If the points in the pool are zero or negative, then the game finishes. Otherwise, the game will last for a number of rounds, until the person facilitating this game announces its end. Thus, the points you earn in the game will depend both on your decisions as well as on the decisions taken by the rest of the group members. Each round of the game is composed by **2 stages**, as described below.

Stage 1

Each player can invest his/her individual endowment in an irrigation project IR that appropriates points from the common pool and/or in a project B without impact on the common pool. The sum of points invested in A and B will be equal to your individual endowment. Group members take investment decisions sequentially. For that purpose, at the beginning of the game you will receive a piece of paper indicating your position in the decision taking process. That is, if the paper indicates 1 it means you are the first in deciding how much to invest in any of the projects IR and B. Before taking your investment decisions, the person facilitating the game will let you know the points available in the common pool and that you can appropriate by investing in project IR.

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[14] 1 US$ = 23.6384 Córdoba (at 31 July 2012).

On the registry sheet, you will write the points you invest in project IR. The difference between your endowment and the points invested in IR will be invested in B. You can invest in IR any point between 0 and your endowment. These are the consequences of investing in project IR and B:

1. Consequences of investing in IR: for each point invested in project IR, you get 2 points, but the common pool decreases by 3 points.

1 point in IR = 2 points for you

1 point in IR = 3 points less in the common pool

2. Consequences of investing in B: for each point invested in B, you get 1 point.

1 point in B = 1 point for you

3. Outcomes from Stage 1: Your income at the end of the first stage will depend on your investment decisions in projects IR and B. It is the income from your investment in IR plus the income from your investment in B. Payoffs of each participant are calculated in the same way:

Payoffs Stage 1 = 2 x investment in IR + 1 x investment in B

At the end of Stage 1, the common pool will vary according to the group investment in project IR:

Total variation common pool = - 3 x Group investment in IR

Variation of the common pool is provided to the group before the Stage 2. This is the information you will have to write on the registry sheet before the group moves to Stage 2:

- Your investment in project IR and B (points)

- The points you appropriate from the common pool = 3 x Investment in IR

- The common pool available for the next player = Points you had available in the common pool – 3 x Investment in IR

- Your payoff from Stage 1

- Total variation of the common pool

Stage 2

In the Stage 2, you have to decide how much from your Stage 1 payoff you invest in a project C that increases the points in the common pool. You can invest any amount between 0 and your payoffs from Stage 1.

1. Consequences of investing in project C: for each point invested in C your payoffs diminish by 1 point. At the same time, each point invest in C increases the common pool by 1.5 points.

1 point in C = 1 point less for you

1 point in C = 1.5 points more in the common pool

The round payoffs will be equal to the payoffs from Stage 1 minus the points invested in project C:

Round payoffs (Stage 1 and 2) = 2 x Investment in IR + 1 x Investment in B − 1 x Investment in C

It is important to keep in mind that:

- Investment in IR + Investment in B = Individual endowment

- Investment in C ≤ Payoffs Stage 1

This is the information you will have to write on the registry sheet in Stage 2:

- Investment in project C

- Contribution to common pool = 1.5 x Investment in C

- Round payoffs

At the beginning of the next round, your endowment will be defined by the payoffs from the previous round. That is, in round 2 your endowment is the payoffs from round 1. Every player will start the game with an initial endowment of 20 points.

Unless the common pool reaches zero or a negative value, the game will be played by a number of rounds. The person facilitating the game will announce the end of the game. Your payoffs at the end of the game will be the sum of the income you obtained in the last round played plus an equal share from the common pool (if points in the common pool are above zero).

If points in the common pool > 0

Game payoffs = Last round payoffs + $\frac{\text{Remaining common pool}}{4}$

If points in the common pool ≤ 0

Game payoffs = Last round payoffs

Appendix 4. Survey on pro-social preferences and risk attitudes

Appendix 4.1 Students' survey

0. Información básica

1_IDexp:		2_Fecha:	3_Lugar encuesta:
4_ID jugador/a (NAA-MMDDAA):			5_Posición:
6_Edad:	7_Sexo: [ ]1_Hombre [ ] 2_Mujer		8_Comunidad/ciudad: [ ] 1_Rural [ ] 2_Urbano
9_Nivel educativo máximo completado [ ] 1_Ninguno [ ] 5_Técnico básico [ ] 2_Alfabetizado [ ] 6_Técnico medio [ ] 3_Primaria [ ] 7_Universidad [ ] 4_Secundaria Carrera:_____			10_En algún momento, ¿Ha trabajado o ayudado a alguna persona en tareas relacionadas con el riego? [ ]1_Sí [ ] 2_No

1_Propensión a cooperar

11_Imagine que una persona amiga suya tiene que decidir entre estas dos alternativas, ¿Cuál cree usted que escogería? (marcar con una cruz donde corresponda)

Tener una finca de 10 mz para el solo	01
Tener una finca de 25 mz compartida con otra persona y sin posibilidad de dividirla	02

12_Imagine que se encuentra ante la siguiente situación en la que tiene que decidir si cooperar o no con otra persona. Si los dos deciden cooperar, entonces tanto usted como la otra persona reciben 100 Córdobas. Si ambos deciden no cooperar entonces ambos reciben 75 Córdobas. En el caso de que usted coopere y la otra persona no lo haga, entonces usted recibe 50 Córdobas y la otra persona 125. Al contrario, si usted no coopera y la otra persona sí lo hace, entonces usted recibe 125 Córdobas y la otra persona 50 Córdobas. ¿Qué decidiría? [ ] 1_Cooperar [ ] 2_No cooperar

		Usted	
		1_Cooperar	2_No cooperar
Otra persona	Cooperar	Otro=100, Usted=100	Otro=50, Usted=125
	No cooperar	Otro=125, Usted=50	Otro=75, Usted=75

13_Imagine que recibe 100 Córdobas y le dan la posibilidad de contribuir voluntariamente a un fondo común compartido con un grupo de 4 personas. Este fondo común genera 4 Córdobas por cada unidad que las personas del grupo inviertan en el fondo común. Es decir, si cada una de las 4 personas del grupo invierte 10 Córdobas entonces llegarán 40 Córdobas al fondo común y se generarán 160 Córdobas (4*40) a repartir a partes iguales entre los miembros. Por lo que cada uno tendría al final del período 130 Córdobas. Por tanto, ¿Qué cantidad estaría usted dispuesto a contribuir de los 100 Córdobas al fondo común? _____

2_Confianza y reciprocidad

14_Imagine que recibe 100 Córdobas y que puede enviar tanto como quiera de este dinero a otra persona. La cantidad que envíe se le dará triplicada a la persona que recibe el dinero. Esta persona luego puede enviarle de vuelta la cantidad que desee. ¿Qué parte de los 100 Córdobas estaría usted dispuesto a enviar a la otra persona? Recuerde que puede enviar una cantidad entre 0 y 100:___

15_Imagine que recibe 100 Córdobas y que puede enviar tanto como quiera de este dinero a otra persona. ¿Qué cantidad de los 100 Córdobas estaría usted dispuesto a enviar?___

3_Justicia y altruismo

16_Imagine que usted y otra persona tienen que repartir 100 Córdobas entre los dos. La otra persona decide primero y le ofrece un trato que usted puede aceptar o rechazar. Si usted lo rechaza, entonces ninguno de los dos recibe plata. Si usted lo acepta, el trato se implementa. Ahora, imagine:

16a_ De los 100 Córdobas la otra persona le ofrece 25 para usted y 75 para él o ella. ¿Aceptaría el trato? [ ] 1_Sí [ ] 2_No -> Ir a 16b
16b_Si le ofrece 40 para usted y 60 para él o ella. ¿Lo aceptaría? [ ] 1_Sí [ ] 2_No -> Ir 16c
16c_¿Qué cantidad estaría dispuesto a aceptar para cerrar el trato?___

17_Imagine que recibe 100 Córdobas y que puede enviar tanto como quiera de este dinero a otra persona que conoce y es su amigo/a y/o familiar. ¿Qué cantidad de los 100 Córdobas estaría usted dispuesto a enviar?___

4_Preferencias temporales y riesgo

18_Se le presentan loterías y usted tiene que decir en cada caso si prefiere la opción A o la B:

Opción A	Opción B	Decisión
1/10 de C$ 46, 9/10 de C$ 37	1/10 de C$ 89, 9/10 de C$ 2	
2/10 de C$ 46, 8/10 de C$ 37	2/10 de C$ 89, 8/10 de C$ 2	
3/10 de C$ 46, 7/10 de C$ 37	3/10 de C$ 89, 7/10 de C$ 2	
4/10 de C$ 46, 6/10 de C$ 37	4/10 de C$ 89, 6/10 de C$ 2	
5/10 de C$ 46, 5/10 de C$ 37	5/10 de C$ 89, 5/10 de C$ 2	
6/10 de C$ 46, 4/10 de C$ 37	6/10 de C$ 89, 4/10 de C$ 2	
7/10 de C$ 46, 3/10 de C$ 37	7/10 de C$ 89, 3/10 de C$ 2	
8/10 de C$ 46, 2/10 de C$ 37	8/10 de C$ 89, 2/10 de C$ 2	
9/10 de C$ 46, 1/10 de C$ 37	9/10 de C$ 89, 1/10 de C$ 2	
10/10 de C$ 46, 0/10 de C$ 37	10/10 de C$ 89, 0/10 de C$ 2	

19_¿Qué preferiría tener 5000 Córdobas hoy o 10,000 Córdobas en un año?
[ ] 1_5000 hoy [ ] 2_10000 un año

Appendix 4.2 Villagers' survey

0. Información básica – socioeconómica

1_IDexp:		2_Fecha:	3_Lugar encuesta:	
4_ID jugador/a (NAA-MMDDAA):			5_Posición:	
6_Edad:		7_Sexo: [ ]1_Hombre [ ] 2_Mujer	8_Comunidad:	
9_Nivel educativo máximo completado: [ ] 1_Ninguno [ ] 5_Técnico básico [ ] 2_Alfabetizado [ ] 6_Técnico medio [ ] 3_Primaria [ ] 7_Universidad [ ] 4_Secundaria Carrera:_____			10_ Relación de persona entrevistada con respecto a el/la cabeza de familia: [ ] 1_Cabeza familia [ ] 4_Madre [ ] 2_Esposo/a [ ] 5_Hijo/a [ ] 3_Padre [ ] 6_Otros.6.1 _____	
11_Estado civil: [ ] 1_Soltero/a [ ] 2_Casado/a [ ] 3_Viudo/a			12_N° personas que habitan en la vivienda (contándose usted):	13_N° personas en la vivienda con ingresos:
14_¿Son ustedes los titulares de propiedad de la vivienda? [ ] 1_Sí [ ] 2_No			15_Activos en la vivienda: Electricidad [ ]1_Sí [ ] 2_No Acceso vehículo [ ]1_Sí [ ] 2_No Moto [ ]1_Sí [ ] 2_No Carro/camioneta [ ]1_Sí [ ] 2_No Cocina gas [ ]1_Sí [ ] 2_No Refrigerador [ ]1_Sí [ ] 2_No TV [ ]1_Sí [ ] 2_No	

16_Cultivos y ganado propiedad de las personas que viven en la vivienda

Cultivo (mz)	Indicar cantidad propia	Tiene título de propiedad 1_Sí 2_No
Sup tierra de cultivo	16.1_____Mz	16.2
Sup cultivo en regadío	16.3_____Mz	16.4
Ganado		
N° de cabezas ganado mayor	16.5_____Unidades	TITULO PROPIEDAD NO APLICA A GANADO
N° cabezas cerdo	16.6_____Unidades	
N° de gallinas	16.7_____Unidades	

17_¿Cuál es la principal fuente de ingreso de las familias que habitan en la vivienda? Agricultura en finca familiar [ ] 1 Agricultura fuera finca familiar [ ] 2 Doméstico [ ] 3 Sector público [ ] 4 Sector privado [ ] 5 Otros:_____ [ ] 6	18_ En algún momento, ¿Ha participado en tareas relacionadas con el riego? [ ]1_Sí [ ] 2_No

1_Propensión a cooperar

19_Imagine que una persona amiga suya tiene que decidir entre estas dos alternativas, ¿Cuál cree usted que escogería? (marcar con una cruz donde corresponda)

Tener una finca de 10 mz para el solo	01
Tener una finca de 25 mz compartida con otra persona y sin posibilidad de dividirla	02

20_Imagine que recibe 100 Córdobas y le dan la posibilidad de contribuir voluntariamente a un fondo común compartido con otras 4 personas. Este fondo común genera 4 Córdobas por cada unidad que las personas del grupo inviertan en el fondo común. Es decir, si cada una de las 4 personas del grupo invierte 10 Córdobas entonces llegarán 40 Córdobas al fondo común y se generarán 160 Córdobas (4*40) a repartir a partes iguales entre los miembros. Por lo que cada uno tendría al final del período 130 Córdobas. Por tanto, ¿Qué cantidad estaría usted dispuesto a contribuir de los 100 Córdobas al fondo común? ____

21. Si hubiera un problema que afectara a toda la comunidad, por ejemplo, una peste que afecte a todos los cultivos de la comunidad, ¿Quién cree que se juntaría para tratar de buscar una solución al problema? (marcar sólo una)

	1_Sí	2_No
1_Cada persona/familia actuaría de manera individual		
2_Los vecinos entre ellos		
3_El gobierno municipal y los líderes políticos		
4_Todos los líderes de la comunidad actuarían de manera conjunta		
5_Toda la comunidad se juntaría		
6_Otros (especificar):_____		

2_Confianza y reciprocidad

22_Imagine que le regalan 100 Córdobas y que puede regalar tanto como quiera de este dinero a otra persona. ¿Qué cantidad de los 100 Córdobas estaría usted dispuesto/a a regalar?___

23_Por favor, indique si en general está de acuerdo o en desacuerdo con las siguientes afirmaciones:

	1_Muy acuerdo	2_Acuerdo	3_Desacuerdo	4_Muy desacuerdo
La mayoría de la gente de esta comunidad es honesta y se puede confiar en ella				
La gente de esta comunidad se interesa mayormente por su propio beneficio				
En esta comunidad hay que tener cuidado o es probable que alguien intente aprovecharse de vos				
Si tengo un problema, siempre hay alguien en esta comunidad para ayudarme				
La mayoría de las personas de la comunidad estarían dispuestas a ayudarme en caso de que lo necesitara				
Si pierdo un cerdo/gallina, alguien en la comunidad estaría dispuesto a ayudarme a buscarlo o me lo devolvería				

3_Justicia y altruismo

24_Imagine que usted y otra persona tienen que repartir 100 Córdobas entre los dos. La otra persona decide primero y le ofrece un trato que usted puede aceptar o rechazar. Si usted lo rechaza, entonces ninguno de los dos recibe plata. Si usted lo acepta, el trato se implementa. Ahora, imagine:

24a_ De los 100 Córdobas la otra persona le ofrece 25 para usted y 75 para él o ella. ¿Aceptaría el trato? [ ] 1_Sí [ ] 2_No -> Ir a 24b
24b_Si le ofrece 40 para usted y 60 para él o ella. ¿Lo aceptaría? [ ] 1_Sí [ ] 2_No -> Ir 24c
24c_¿Qué cantidad estaría dispuesto a aceptar para cerrar el trato?___

25_Imagine que recibe 100 Córdobas y que puede enviar tanto como quiera de este dinero a otra persona que conoce y es su amigo/a y/o familiar. ¿Qué cantidad de los 100 Córdobas estaría usted dispuesto a enviar?___

4_Preferencias temporales y riesgo

26_¿Qué preferiría tener 5000 Córdobas hoy o 10,000 Córdobas en un año?
[ ] 1_5000 hoy [ ] 2_10000 un año

27_A continuación se presentan una serie de loterías que puede elegir. Si sale cara gana la cantidad que aparece en la columna de la izquierda y si sale cruz gana la cantidad que aparece en la columna de la derecha. Tiene que decidir a qué lotería preferiría jugar:

Lotería	Cara	Cruz
O	50	50
A	45	95
B	40	120
C	35	125
D	30	150
E	20	160
F	10	190
G	0	200

5_Participación y liderazgo

28_Indicar en qué organizaciones participa y si es líder:

Organización	Participa 1_Sí 2_No	Líder 1_Sí 2_No
CAPS		
Cooperativa		
CAS		
Comité microcuenca		
COMACo		
CPC		
CDM		