

**Can cooperation lead to improved performance in groundwater management?
Some reflections on the experience of Spanish groundwater user groups**

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1. Introduction

Cooperation by users has long been heralded as a potential solution to the drama of the commons posed by groundwater. Yet this paper will “unpack” the different shades of cooperation to try and identify which are the key factors that make it more probable to enhance cooperation which can ultimately facilitate improved performance in groundwater management. In this sense the focus for cooperation in this case is as *a cause for action* to manage groundwater within resource boundaries. In terms of characterising cooperation, this paper will look at two interconnected aspects, process and outcomes from groundwater management by users. In this sense it looks at the concept of groundwater governance as underpinned by a series of principles which are based both on process and outcome criteria, and where both are highly related (Lautze et al, 2012). Work presented here is work in progress, and thus only preliminary results will be presented on data currently being collected and analysed to on range of relevant criteria. Some of the questions posed relate to for example, does the way users are organised influence governance outcomes? How do the rules of the game facilitate (or absence of rules hinder) the specific goals or targets set?. Collective management by users is the most basic level of decentralized management, which places special emphasis on the whole spectrum of collaboration spanning from non-cooperation to co-management between users and regulatory bodies. The insights into these different modes of cooperation in the case of groundwater management are applied to the specific case of Spanish groundwater user groups, as embodied in Spanish legislation. Under Spanish law, these “cooperative” arrangements with users are one of the basic measures to manage, regulate and control the use of groundwater resources.

The paper is structured in three different sections to sequentially characterise collective (understood as cooperative) groundwater management, to ultimately evaluate their performance. The first section analyzes the history of user cooperation on water and the diversity of different organizational entities of users and the root causes why users are organized in these collective entities for good resource management. The second section, building on the characterisation of groundwater users groups, analyses their performance by looking at whether the governance factors identified in the literature explain or not the most

successful co-management with groundwater users; the final third section, characterises these range of governance arrangements along a cooperation spectrum.

2. Definition and characterization of collective management of groundwater

One of the most fundamental problems facing groundwater management is due to the asymmetric information between users and the regulatory agency. Most often the regulator, in the case of Spain the River Basin authorities or regional water agencies, face large transaction costs in terms of obtaining reliable and updated information on the use (and misuse) of the resource. Although this is likely to change, in part due to the use of remote sensing, it is currently estimated that the authorities have information on about 20% of existing wells. The remaining 80% is controlled by the user, not controlled or unknown. Therefore, there is a problem of lack of information and the associated difficulty on controlling the actions of thousands of users in a common resource such as groundwater.

The management and control on groundwater extraction is a difficult and complex task, both at level of the basin and at the aquifer level, where it challenging to obtain an accurate overview on ground water uses and abstraction levels. The case of Spain is symptomatic to other cases globally, and this inherent resource problem is further enhanced or complicated due to poor regulatory design of the main 1985 water law in relation to groundwater. The Spanish water law in fact unravelled a complex maze of types of water rights, combined with a substantial lack of resources, at the time of the introduction of a deep regulatory reform and an underestimation on the potential costs of implementation. The critical time of the period 1985-1988, created a path dependence of lack of knowledge, monitoring and control, and a fully functioning enforcement regime, when groundwater became part of the public domain. This lack of financial and human resources, combined by a lack of information, data and knowledge, made it impossible to make a reliable inventory of water rights and withdrawals (Sahuquillo et al, 2009). This has deeply imprinted the performance of cooperation arrangements on groundwater management more than twenty years on. It highlights that the initial conditions have a deep impact on the emergent behaviour of cooperative (and non-cooperative) arrangements.

Yet, as will be discussed below for the case of Spain, there is an increasing number of examples of users and their representatives, who motivated by a common interest (normally the appreciation on the socio-economic value of groundwater and their claim of access to the resource), had the motivation to self-organise. The reciprocal reaction by the administration was patchy, where only in some cases, users received appropriate support and legitimation by the competent authorities. Yet the *development of cooperative arrangements* may be one of the key elements for conservation and management of groundwater resources, by establishing strong relationships to successfully regulate users activities (Ostrom, 1990, Rica et al, 2012, Lopez-Gunn, 2007). The level of the user is most atomistic level, and - provided robust institutional arrangements are in place (i.e. the rules of the game between the players) - for water it can be an "ideal" scale for management since the combination of local and basin centred means that water resources planning and management can follow the principle of subsidiarity. This is when authorities at higher levels do not perform functions that can be *de*

facto delegated, in some cases also *delegated de jure*, and performed more efficiently by smaller entities at a more local devolved level (Custodio, 1996).

2.1. *The logic of collective action in Spain*

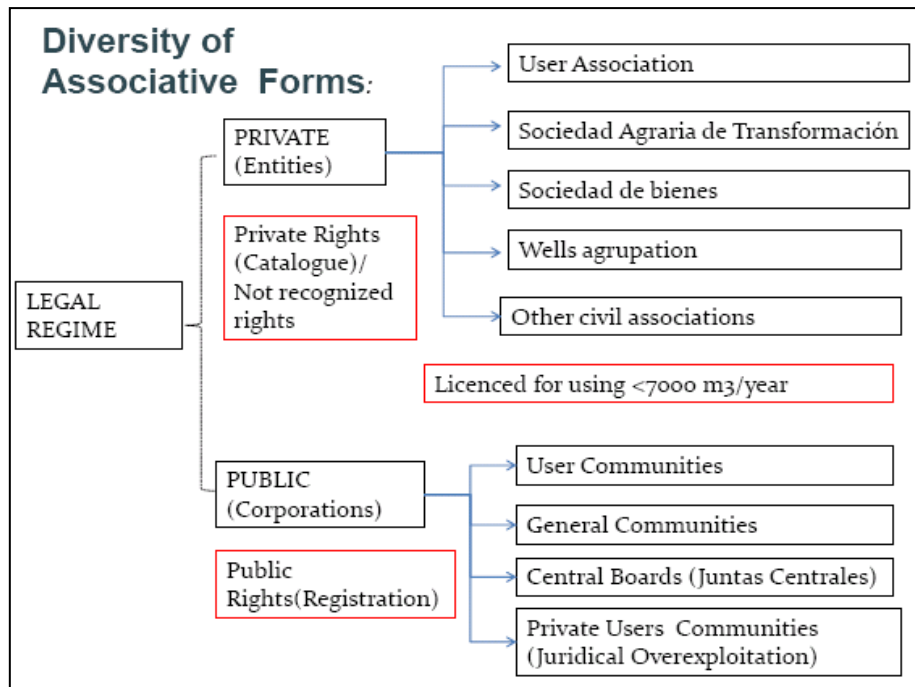
Collective management, co-management and self-regulation are options for resource use and conservation. Yet despite its wide discussion in the commons literature these do not emerge in all cases. Despite the apparent logic of collective action, this management model is given only in certain situations (Ostrom, 1990, Ostrom, 2007). According to Meinzen-Dick et al (2004). Collective action requires the participation of a group of people with a shared interest in achieving some kind of common activity, to ensure the object of interest. For this reason, some authors prefer to call it *mutually beneficial collective action* (Uphoff, 2000). Depending on their action or collective goal, this action can take many forms, including the development of institutions or rules for resource management, coordination of activities, monitoring or information exchange.

Spain, along with countries like Mexico and India, has gained invaluable experience in a number of regulatory initiatives led by users (Shah, 2009). Well known worldwide for its ancient tradition of irrigation communities of surface irrigation (see the case of Heredades in the Canary Islands), in Spain nearly 60% of irrigated land is in the hands of irrigation communities or other of collective entities (Valero de Palma, 2011). In the case of groundwater, there is now half a century of experience from the oldest associations of groundwater users accompanied more recently by a new trend in the emergence of new organizations, where often the litmus test for successful performance is measured increasingly based on aquifer management in a sustainable manner (understood as sustainable yield). This paper will argue that although this can be seen as the ultimate goal, there are many preconditions that might have to be met on the way to the holy grail of sustainable “groundwater management” by cooperative arrangements

Spain is one of the countries in the world with a longest history of user cooperatives on water. The history of surface water users organised in irrigation communities spans almost a thousand years, with groundwater user groups appearing from the 1970s a decade after the onset of the technology in the 1960s that had allowed for the first time the medium to large scale intensive abstraction of groundwater for different uses, but mainly for irrigation like the cases of the Upper Guadiana basin. The last wave of collective organisations and cooperative arrangements for water management has recently witnessed new emerging collective groups to manage “new” water like desalinated water in the field of Níjar (Almería), the artificial recharge aquifers like Santiuste (Segovia) or recycled water in the Lower Andarax (Almería) (see Table 3 below). Thus the emergence and evolution of collective institutions have experienced three waves. The first wave refers to the long and well-documented history of surface water communities. The second wave refers to the emergence of institutions of groundwater users cooperative arrangements under different organizational types (irrigation communities, well groups, Agricultural Transformation Societies, etc.). The third wave marks the recent appearance in the last 5 years or so of user groups related to the use and operation of a new range of water as water desalinated or recycled water, made possible by advances in

technology and knowledge. As will be discussed below briefly (for more detail see Rica et al 2012) the analysis of the second wave, the collective institutions of groundwater, shows that most have been developed through the initiative mainly by users across a wide spectrum of organizational forms, both in the public and private. This largely reflects the diversity of groundwater rights (Figure 1).

Figure 1. Correlation between the rate of duty and the type of collective entities (source: Rica et al, 2012).



Yet groundwater management is intrinsically different to surface water management. First, institutions for the management of surface water have been developed over centuries from traditional hydraulic societies, around centuries old canals and ditches like the Acequia Real del Júcar. In comparison, groundwater institutions have a relatively short tradition and much less accumulated experience (including experimentation, trial and error basic to institutional arrangements). Second, groundwater is a “hidden resource”, which in many ways influences or hinders the immediacy or application of social norms like “name and shame”, since it is easier to free ride and more difficult to attribute causality. Third, the relatively low upstart investment has meant an emergent individualistic mode of exploitation, often spontaneous and disorganised from the point of view of the central administration, complicated by its exponential growth as seen in the increase globally of intensive use of groundwater. Once it starts it is often difficult to halt if the economic benefits outweigh the social and environmental external costs, which are normally borne by society at large (Llamas and Custodio, 2002; Llamas and Custodio 2003, Llamas and Martinez Santos, 2005).

In terms of organisational types for participatory groundwater management, we can identify two types of systems: on the one hand collective wells that are managed similar to surface water systems, where individual farmers take “shares” on a common well owned in a cooperative arrangement with other farmers and, on the other the exploitation of individual

wells by farmers to achieve a highly productive agriculture. In this second case, to manage risk individual users must be internally or externally be persuaded that the benefits of self-regulation outweigh the costs, and that default in commonly agreed standards is sanctioned either formally or informally. In the case of Spain there is evidence (Rica et al, 2012) that most cooperative arrangements for groundwater management have been created due to external incentives, yet have arisen spontaneously. That is, cooperative arrangements have formalised and been institutionalised into groundwater user groups through bottom up user initiative but in response to an external trigger, most often a threat to close groundwater resources by the regulator and/or the onset of a drought. That is the experience of top down creation of groundwater cooperative arrangements has been infrequent and no groups have been created without an external trigger.

Table 1: Creation and emergence of cooperative institutions between groundwater users

	Creation Top down	Emergence Bottom Up
External incentives		
Internal Incentives		x

2.2. *The public/private nature of groundwater user communities in Spain*

One of the most peculiar aspects of many (not all: see below) a groundwater community in Spain is that these are legally part of the administration in this case, river basin authorities. Thus these are true public/private partnerships where there are two main benefits: first, these groundwater user groups are entitled to receive public funds for their operation and on occasion sign one off agreements for specific issues (e.g. like the case of Eastern Mancha for monitoring and control) and second, they can impose sanctions on their members when these are on points of fact not of law. The main limiting factor is that to adopt a PPP type of cooperative arrangements water rights have to be public concessions rather than private water rights. Thus some organisation mainly for this reason but also for tax and historical reasons have opted to keep a purely private nature, This is the case of Private water User groups like those of Campo d Montiel, and also Well Syndicates and SATs, which are mainly located along the Mediterranean coast. These different types of groundwater user groups are economically very important since they tend to be located and operate in areas where water productivity is generally higher than that exhibited by the majority of the more than 7,000 traditional irrigation communities. The area covered by these different types of user groups can range from areas of 300 km² to areas of 7,000 km².

2.3 *The emergence of collective action by users*

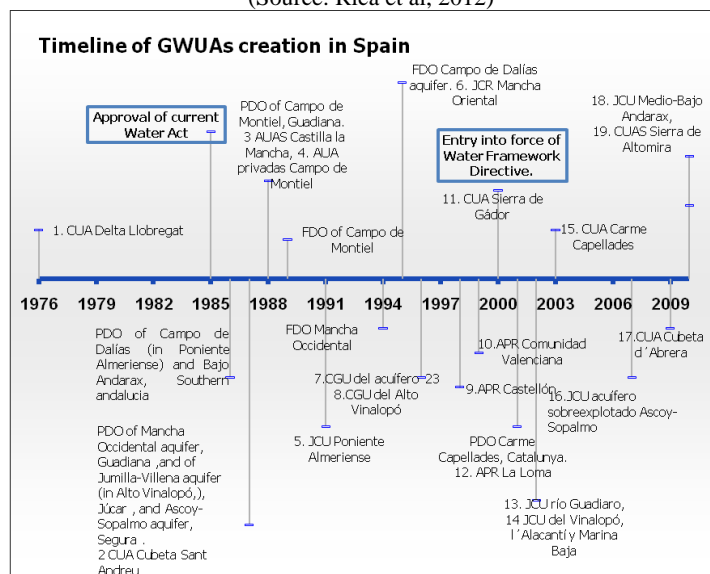
The first and most pioneering groundwater user organization was formed in 1976 in the Delta del Llobregat, and since then there have been at least 19 other collective institutions set up. These 19 groundwater cooperative institutions have been formed with the aim of managing groundwater and associated issues that affect users from the same groundwater body or aquifer (Figure 2). Some of these entities have been created as a result of the official Declaration of overexploitation of the aquifer, which is a proviso under Spanish law for those aquifers where more resources are being abstracted than those available. However, in most

cases users did not organize to comply with the regulation that dictates the creation top down of collective institutions once aquifers are declared overexploited. In most cases users have come together to address their response (and thus their collective voice and strength) in a coordinated manner to the measures imposed by the various water authorities to correct the situation of overexploitation. Only in a minority of cases have these collective institutions emerged to seek a more efficient resource management through coordinated action (e.g. Delta del Llobregat). Equally only a minority were created under the direction of the state, as a result of this legal proviso in declared overexploited aquifers, which obliges the forced constitution of users associations. Thus this highlights a range for the creation of water user cooperation groups, spanning from those that were created fully spontaneously to those that were created top down by the administration. As will be seen below these initial conditions have, in turn, marked the effectiveness of their performance. Those that emerged bottom up and had the support from the administration, have fared best as compared to those that emerged bottom up but had little support from the administration. Equally those that were created top down but had little buy in from users have had a patchy more erratic performance in terms of water management, needing the input of external incentives as an example of extrinsic motivation rather than the intrinsic motivation witnessed in the self-emergent ones. It is a clear case on the importance of social capital and legitimacy in the performance of institutions.

Fieldwork conducted by the Water Observatory in the period 2010-2012 (and ongoing) confirms that most organizations emerged spontaneously due to the collective interest of users (Rica et al., 2012), as a reaction to drought in some cases, and in most cases, to defend their private water rights, when facing a potential declaration of overexploitation. The most interesting case is a new factor that influences the binding of groundwater users – as a clear example of collective action - is their collective action not only for energy but for the water/energy nexus, to negotiate collectively for more favorable rates through a greater bargaining power with the energy companies.

Figure 2. Chronology of the emergence of collective management bodies and aquifer Declaration of Overexploitation (PDO=Provisional Declaration of Overexploitation. FDO=Final Declaration of Overexploitation)

(Source: Rica et al, 2012)



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Apart from the main reason for the creation (top down) or emergence (bottom up) of cooperative agreements between users, another interesting criterion, as discussed earlier is their legal nature. Oftentimes their legal nature- mainly divided into public or private does condition up to an extent their operating space and the range of actions available to them, where the public/private nature of user groups in some ways gives them advantages in theory (e.g. access to subsidies and ability to sanction). However, some users have opted for the private cooperative arrangement. This is mainly for two reasons: one reason is cultural and historical, where important factor in defining the nature of the organization is the tradition and culture of the region. Many associations of groundwater users on the Mediterranean coast have chosen civil associations, such as the Agricultural Transformation Societies, because of its historical prevalence in the area. The second reason is their preference to keep their water rights private, partly explained a low level of social capital with the administration and a reluctance to convert their private rights in state concessions as allowed under Spanish law. The case of Catalonia is an exception, possibly because the dominant use is industrial and public water supply, as well as the social capital gradually built up with the administration, which thus opted for state concessions in order to qualify for administrative protection against third parties, in case of disputes

3. Evaluation of the key factors in the governance of groundwater

In the case of Spain, the few examples of groundwater users associations that have become effective resource managers have three things in common: first they have managed to secure access to the resource in a stable agreement with the regulator, which is either formalized into water rights or as a gentleman's agreement, subject to constant re-negotiation, second they have mutually accepted rules established on the access and use of resources which is backed up by a strong sanctioning regime where users themselves are actively involved through the clear establishment of social norms, penalties for deviant behavior and support by the regulator for those that show repeated deviant behaviour and thirdly, these organizations have been supported by the "official" Administration which provides legitimacy and endorsement to their actions, as well as stable predictable frame for management. The variety of circumstances under which users operate these associations, their ability to bring together thousands of independent users and sometimes manage large complex, aquifer systems, or the way some water groups are working in cooperation with the authorities water to establish sustainable management regimes, are important advances and potential test of co-management model. The level of devolution from the Administration to the users depends on the context. Still, the experience and empirical data are providing insights into aspects of collective management that can increase the chances of success. Box 1 summarizes some of the factors that make more likely to develop robust cooperative arrangements. It is also essential to consider the most problematic aspects of collective management, i.e., recognize and show some caution about possible unintended consequences, such as the capture by local elites or agricultural unions, inequality of power between different users, lack of implementation of internal sanctioning regimes, etc.

**Box 1: Factors to consider when creating an association of groundwater users
(source: Lopez-Gunn and Rica, 2012)**

- Representation of all users, including small farmers, urban users and the environment, balancing the over-representation of large landowners and agribusiness
- "Solvency" legal or legitimacy in terms of responsibility
- "Solvency" legal or legitimacy in decision making
- Eliminate or reduce the strength of government participation and power sharing
- Existence of aquifer management plans
- Suitable regimen compliance and fair disciplinary system and operational
- Untying reductions and economic benefits extractions
- Co-management rather than consultation.
- Organizational structure (leadership position and responsibilities)
- Mechanisms transparent in decision
- information and education services to users and the general public
- Activities and clearly defined roles
- Access to technology and monitoring methods
- Technical support and assessment processes such technical and administrative procedures,
- Training in administrative participatory groundwater management

For the evaluation of groundwater user groups we have tentatively developed a criteria based on criteria identified by the literature for good governance and complemented it by criteria on self-governance systems to come up with a list of variables to assess the level of alignment with the best cases of water cooperation with these specific criteria. So far, this analysis is preliminary since no weighing has been undertaken on the rating exercise. The exercise of evaluation however, serves a dual purpose since it can be used on the one hand to plot water cooperation along a scale based on number of criteria fulfilled, and also see whether it coincides that, the higher the number of criteria met, the better the performance in terms of the litmus test of groundwater management. The preliminary results of this analysis are shown in the diagram of Figure 3, where the key (preliminary) criteria for success seems to relate to water rights, trust and monitoring and sanctioning. If these three criteria are not met, then there is limited or rather sporadic or uneven cooperative action in relation to the conservation of groundwater quality and quantity. Thus the robustness of water rights, a clear penalty system, and their its implementation due to strong social capital between users and the regulators (Lopez-Gunn, 2012), make it more likely that positive action is taken in terms of active co-management of the resource between users and the regulator, for this paper, a key criterion for strong performing institutions.

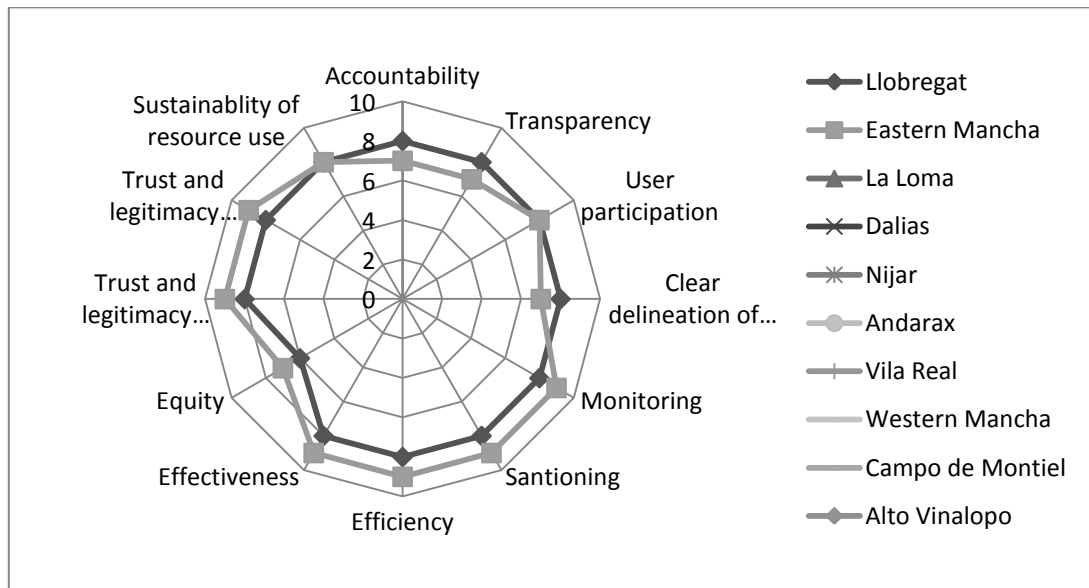
The main criteria in the first round of evaluation was derived from literature on governance, the main criteria which were preliminarily evaluate and which is now being updated was based on: accountability, enforcement, transparency and accessibility of information, participation, responsiveness, effectiveness, efficiency, equity, sustainability and solidarity.

**Box 2: Criteria used to evaluate water user groups performance in terms of robust governance
(own elaboration on basis of Lopez-Gunn and Rica 2011)**

- *Accountability*: Periodical (e.g. annual) annual budgets and expenditure items
- *Transparency in management*: Defined as easy access to information and data relevant to the use and access of water in the aquifer, usually supported by a web service, or similar newsletter
- *User participation*: is defined as regular participation in user organization measured as attending meetings, consultations, feedback and general involvement of users in decision making directly or indirectly
- *Clear delineation of access to water*: Defined as clear demarcation and control who has access to water as a limited resource.
- *Monitoring*: defined as the existence of a system either through direct methods such as remote sensing

- flow meters or indirect in the use and application of water.
- *Sanctioning regime*: defined as the existence of a clear system of sanctions backed by law and applied regularly to the support of users and their representatives.
- *Efficiency*: defined as a water use it productively and with a high level of technology
- *Equity*: defined as a water access distributed relatively equally among users and / or organizational structures bases good representation pe CRRs.
- *Trust and legitimacy* internal social capital: trust between different users. External social capital: relationships of trust and cooperation with the regulatory agency
- Sustainability in resource use and boundaries: management aligned with available resources at different scales, adjusted to information from water levels and water quality, aware of potential impacts on associated ecosystems

Figure 3. Diagram with evaluation results of governance in communities of groundwater users (Lopez-Gunn and Rica, 2011).



Thus preliminary results from the evaluation of these range of collective management models show that there is potential organizational capacity and management in many of these entities, which also can benefit from the economies of scale that occur when acting as a group. However, contrary to the literature, this potential has only been realized in a handful of cases. There is still a way to go and room to develop closer cooperation on key pending issues like the inventory of rights, the establishment of collaboration agreements with basin organizations or how to reinforce the sanctioning system. Resource conservation issues in optimal condition for use and also the protection of groundwater associated ecosystems are still outstanding issues in the model of community governance and co-management between basin organizations and user organizations. It seems that, in order to achieve success, investment should be made in terms of stronger governance on issues like technical user training, information exchange and mutual trust between entities and institutions.

4. Typology of cooperation arrangements: are these linked to performance?

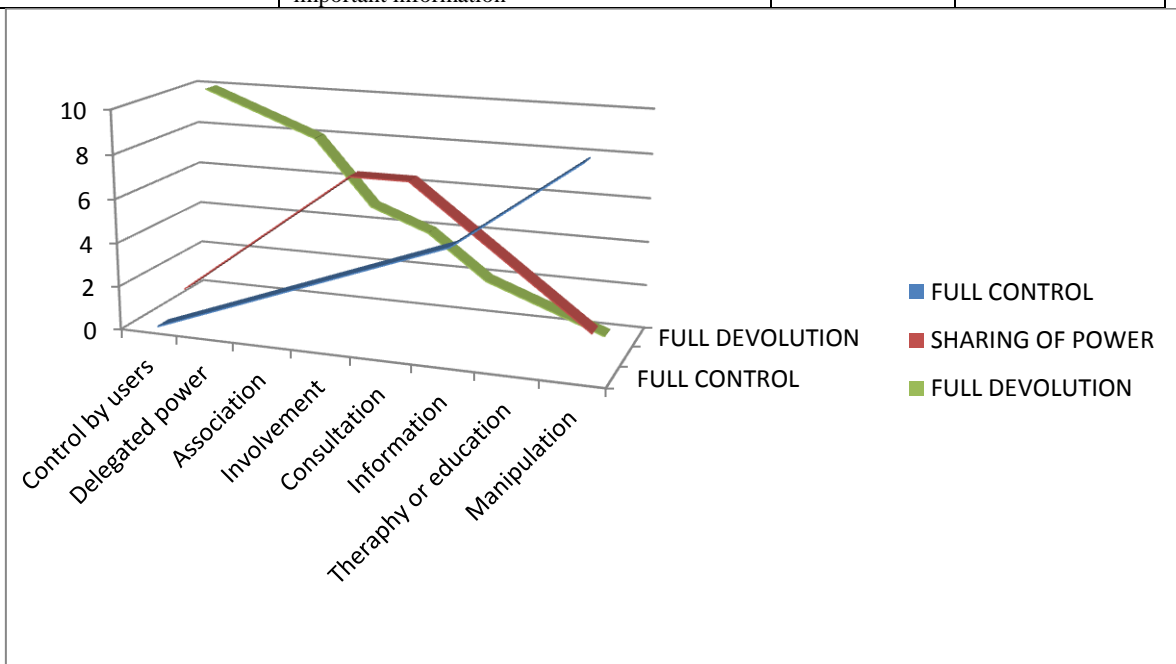
This section includes a preliminary analysis of data on the range or spectrum of cooperation arrangements along a continuum of decentralization to users from the administration using criteria based on power and devolution between users and the regulator. However the difference in this analysis is that this range of “cooperative arrangements” is evaluated from

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the perspective of their ability to manage resources sustainably. Although the term “sustainably” is in itself sometimes slippery, for the purpose of this paper it is understood primarily as having the added value of securing socio-economic development whilst also ensuring the continued functioning of the resource base into the future, so there is no irreversible damage. Thus one first typology can be drawn from the participation ladder proposed by Arnstein and modified for our purposes. What is most interesting is that there is a high level of correlation between those organisations that have successfully fulfilled the three key criteria outlined above (on security of water rights, sanctioning and strong social capital) with those user groups that are on the cooperation continuum that leans towards devolution to users.

Table 2 and Figure 4: Participation continuum in groundwater management
 (from Lopez-Gunn and Rica, 2011 modified from Arnstein, 1969)

DEVOLUTION TO USERS	DESCRIPTION	CONTROL BY REGULATOR	COOPERATION CONTINUUM
Control by users	Self-management in decisions and actions	Power devolved or shared with users	Self-governance
Delegated power	Some power is delegated		Co-management
Association	Bargainning and negotiation with those in power over roles, responsibilities and level of control	Symbolims rather tan participation	Partnerships
Involvement	Opinions bear some weight and have a level of infleunce bu the final decisi3n is taken by those already in power		Collaboration
Consultation	People have a voice but no no rela power to ensure or guarantee their opinions are taken into account		Coordination
Information	Users are informed on what is happening or what will happen	Without power to users	Consultation
Therapy or education	Some power is delegated , some information is shared but this could be, partial or incomplete		Hierarchical management
Manipulation	A passive flow of information where information could be incorrect inaccurate o partial withholding the most valuable or important information		Autocratic management



5. Conclusion

Given the nature of groundwater and the cooperation dilemmas that it entails, it is necessary to support and encourage collective action by users while ensuring the integrity of the resource. As discussed above, in Spain these groups may have different legal, organizational forms, functions, scope and diversity of resources. There has been no single pattern due to the large private and local initiative, in developing the exploitation of groundwater. Cooperation has arisen mainly from the bottom up and only in exceptional cases has developed top-down, mandated by the Agency basin. Users often have the advantage of being the owners of the infrastructure required for the extraction and distribution of water. However in most of the groups do not have enough capacity, power, legitimacy or independence to make decisions on the resource.

The final conclusion of the potential and current reality on cooperative management to enhance performance on resource management is that collective management by users is necessary but not sufficient for good governance of the resource. For a model of self-management or co-management to work it would be essential to implement the right intrinsic incentives to make the management of groundwater in line to an adjustment to available resources sustained into the future without having to recourse to external incentives, to ensure the long-term benefit. Actions such as declaring aquifers overexploited and then fail to develop or follow through on abstraction plans or implement them without public consultation have given the wrong signal and not provided adequate incentives for users to fulfill their responsibilities to participate and self-control to stop overexploitation, a case of punishment without too many alternatives. Good governance at the level of cooperative arrangements is however not impossible. Spain shows that collective action has emerged and the most successful have been able to operate with delegated government functions, obtaining and handling information that the River Basin could not manage on their own (or would be very expensive): It is a breakthrough in achieving the objective of organizing and planning the most beneficial use for all aspects of groundwater resources.

References

- Custodio, E. (1996) Explotación racional de las aguas subterráneas. *Acta Geológica Hispánica*, **30** (1-3), 21-48.
- Campbell, B., J. A. Sayer, P. Frost, S. Vermeulen, M. Ruiz Pérez, A. Cunningham, and R. Prabhu. 2001. Assessing the performance of natural resource systems. *Conservation Ecology* **5**(2): 22. [online] URL: <http://www.consecol.org/vol5/iss2/art22/>
- Lautze, J., de Silva, S., Giordano, M., & Sanford, L. (2011). Putting the cart before the horse: Water governance and IWRM. *Natural Resources Forum*, **35**, 1–8
- Llamas, R. and Custodio, E. (2002) Acuíferos explotados intensivamente: conceptos principales, hechos relevantes y algunas sugerencias. *Boletín Geológico y Minero*, **113**(3), 223-228.
- Llamas, R. and Custodio, E. (2003) *Intensive use of groundwater: challenges and opportunities*. Balkema, Lisse.
- Llamas, M. R. and Martínez-Santos, P. (2005) Intensive Groundwater Use: Silent Revolution and Potential Source of Social Conflicts. *Journal of Water Resources Planning and Management*, **131**(5), 337.
- Llamas, M.R.; Fornés, J.; Hernández-Mora, N. & Martínez Cortina, L. (2001). *Agua Subterráneas. Retos y Oportunidades*. Mundi Prensa Ed. , Fundación Marcelino Botín.
- López-Gunn, E. (2007) Self-regulation as an alternative for the future? Groundwater management in Spain in *NGWA Press, The Global Importance of Groundwater in the 21st century*. Sevilla, 345-350.
- López-Gunn, E. & M. Rica (2011) La Participación activa de los usuarios: la auto-regulación como forma de gobernanza del agua subterránea Congreso Ibérico sobre las aguas subterráneas: desafíos de la gestión para el siglo XXI (AIH- Grupo Español), 14-17 Sept Zaragoza.

DRAFT- PLEASE DO NOT CITE WITHOUT PERMISSION

- Lopez-Gunn, E. (2012) Groundwater governance and social Capital *Geoforum* 43 1140–1151
- Meinzen-Dick, R., Digregorio, M., and McCarthy, N. (2004) Methods for studying collective action in rural development. *Agricultural Systems*, **82**(3), 197-214.
- Ostrom, E.. (1998) A behavioral approach to the rational choice theory of collective action. *The American Political Science Review*, **92**(1), 1-22. Ostrom, E. (2007) A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America*, **104**(39), 15181-7.
- Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.
- Ostrom, E. (2007) A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America*, **104**(39), 15181-7. [online] <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2000497&tool=pmcentrez&rendertype=abstract>
- Rica , M., Lopez-Gunn, E and Llamas (2011) The edge of scarcity: Institutional Diversity and incentives in collective action: groundwater user groups and their role in SES resilience Special Session convened by Lopez-Gunn, Van Cauwenbergh, N. and Mukherji, A. on Collective action in a globalised world XIV *IWRA WORLD CONGRESS* Porto de Galihnas, Brasil Sept.
- Rica, M; Lopez-Gunn, E. y Llamas, M.R. (2012) An analytical framework on the emergence and evolution of collective action: an empirical case of Spanish groundwater user collective associations *ICID Irrigation and Drainage journal*
- Sahuquillo, A.; Custodio, E. & Llamas, M.R. (2009). La gestión de las aguas subterráneas. *Tecnología del Agua*, first part: February, pp. 60–67; second part: March, pp. 54–67.
- Shah, T. (2009). *Taming the Anarchy. Groundwater Governance in South Asia*, Washington DC, USA: Resources for the Future, IWMI.
- Uphoff, N. (2000) Demonstrated Benefits from Social Capital: The Productivity of Farmer Organizations in Gal Oya, Sri Lanka. *World Development*, **28**(11), 1875-1890.
- Valero de Palma, J. (2011). Retos Institucionales de la gestión colectiva del agua en España. Seminario sobre gestión colectiva de las aguas subterráneas en España. Observatorio del Agua de la Fundación Botín