Institutional Diversity and incentives in collective action: groundwater user groups and their role in SES resilience

Marta Rica[1], Elena López-Gunn[2] and Ramón Llamas[3]

[1] *PhD candidate at the Water Observatory, Botin Foundation, Complutense University of Madrid. marta.rica@geo.ucm.es*
[2] *Senior research fellow, Water Observatory Botin Foundation, Complutense University of Madrid.*
[3] *Director, Water Observatory, Botin Foundation, Complutense University of Madrid*

ABSTRACT

Different groundwater user groups have emerged both in the field of public and private law, besides individual initiatives, represented through different levels and types of organization. In this paper we analyze the institutional diversity with regards to the influence on these different organisational forms and how this diversity impacts (or not) on resource management by zooming in into each type of organization, the motivation by users to join and participate and impact collective action has on groundwater use and its dependent ecosystems. The study uses a Social Ecological Systems framework to study three groundwater basins in the SE of Spain, in order to compare and evaluate collective action initiatives. The study shows that there are differences in the nature and interests of user organizations, their effectiveness in managing groundwater and the success of different initiatives by users to maintain the resilience of the whole SES. Results show that priority is given to the social subunit which is becoming more resilient with the introduction of alternative sources to the system, it is less clear whether this also applies to the ecological system which by definition means that only one part (the social) of the social ecological system has increased its resilience though the collective action by users.

Keywords: groundwater, resilience, collective management

INTRODUCTION

In Spain, groundwater has been a key element for the economic development of certain areas, especially those where due to the dominant Mediterranean climate surface water resources are vulnerable to drought. However, groundwater was not really included into water policy in Spain rather it was an afterthought until the a “boom” in its use from the 1960s due largely to private initiatives (sometimes originally incentivised by public agricultural irrigation policies) had already taken place (Llamas and Martínez-Santos, 2005). Groundwater was considered as a private good until 1985, when a new Water Act was approved to change the “rules of the game”, but leaving a high number of uncertainties in relation to its practical implementation. One of the main incognitas refered to the co-existence of both private and private water rights. As will be discussed below, in this context where two different property rights regimes apply, this is linked or reflected in the emergence of different user initiatives.

In this context analysis which bring Integrative approaches, trying to connect social and natural sciences have defined scenarios where people make use of a resource – or cases where an ecosystem provides a resource to a social unit- as complex Social Ecological Systems. The question addressed in this paper is how robust or resilient a particular configuration of a Social Ecological System (SES) is to both external and internal disturbances. This is particularly taken into account to reflect on how collective action by “ecosystem users” determines the management trajectory on the use of the natural resource base.

To address this, a case study area in the southeast of Spain was selected with three different sub-units which were analysed from a SES perspective. In these three separate sub-units which share a number of common elements (culture, history, political and administrative boundaries, climate, etc),also share one major common element relative to the study of SES systems and common pool resources: in all of them there is a defined socioeconomic unit directly benefiting and largely

dependent on groundwater resources. Here different organizational structures have emerged and currently exist to govern groundwater resources to the system. As will be discussed below, hitting the resource limits has partly led to the search for additional resources with frontier mentality.

CONSTRUCTING SOCIAL ECOLOGICAL SYSTEMS

The key components of the SES are individuals, institutions, and the natural resources these use and manage. **"**Social-ecological systems can be viewed as complex adaptive systems, in which the components, and the structure of interactions between the components, adapt over time to internal and external disturbances" (Anderies *et al*, 2004). By internal disturbances we mean changes in the components of the system. It must be added that groundwater, the key resources of "our" SES, are considered Common Pool Resources (CPRs), since extractability by one user affects availability to others, and excludability from using the resource is difficult to control, i.e. common Pool Resources (CPR´s), as described by Ostrom (1990). Groundwater, as hydro geological units, are a common pool resource where extraction by an individual is difficult to control, and where individual decisions on how to use the resource influence availability for the collective. With this setting, disturbances could be a cause and a consequence of all beneficiaries acts.

Decisions driven by self-interest will increase consumption of the resource, regardless of the potential social and environmental consequences, not desired by the group of users as a whole (the so called Tragedy of the Commons). When cooperation does not take place, a social dilemma known as a CPR dilemma can take place (Van Vugt 2002, Ostrom 1998). However, it has been shown that users, with a common objective, have the capacity to cooperate for the conservation and management of the resource used in common, self-regulating their activities, not necessarily leading to a CPR dilemma (López-Gunn, 2006). This control at the collective level by individual users lead can happen spontaneously through user's initiative, or It can be imposed by government authorities. The same users can self-organize in order to share the resource, taking the initiative of collective action. On the other hand, authorities like e.g. central government can incentivise the formation of Users Associations, a decentralization attempt, like the Spanish case where groundwater user were created topdown as a measure to avoid groundwater intensive use,. However, evidence on the slow and rare emergence of groundwater user associations in Spain (Llamas *et al* 2001), highlight that this "top-down" measure did not have the success it was hoped, and issues such as water rights regulation were not solved.

This paper willl use the concept of resilience, first introduced by the ecologist Holling in (1973), as a hot topic which is being used in several research fields besides ecology such as psychology, economics, or sociology It summarises the magnitude of the disturbance that can be tolerated before a system moves into a different region of state space and a different set of controls (Holling 1996). It has also been called robustness with a similar same meaning, "A SES is robust if it prevents the ecological systems upon which it relies from moving into a new domain of attraction that cannot support a human population, or that will induce a transition that causes long-term human suffering". (Anderies *et al*, 2004). Carpenter *et al*(2001) highlight three properties for resilience, namely a) the amount of change the system can undergo; b) the degree to which the system is capable of self organization; c) and the degree to which the system is able to learn and adapt. However, despite the integrative view of the SES approach, and in particular when looking at resilience, it may be important to take as separate sub units of analysis the social and the ecosystem or resource subunits., to better understand their mutual interactions.

ORGANIZATIONS AND INSTITUTIONAL DIVERSITY OVER THE HIDDEN GROUNDWATER RESOURCES

Spain has a long tradition on free associations and collective action regarding water use, mostly with surface water irrigation. According to Valero de Palma (2011) almost 60% of irrigation land is in hands of irrigation collectives. From 1985, both surface and groundwater are considered part of the public domain, although legally as stated earlier those users that had private rights before 1985

were permitted to keep those tights as private right holders. As North (1990) states institutions can be considered the rules of the game and the organizations as the players, and therefore the fact that two property right regimes exist in Spain has – as will be discussed- heavily influenced the existence of different type of organizations to manage water in Spain (Figure 1).

Ramos Gorostiza and Merino de Diego (1998) argued that the diversity in irrigation communities in Spain´s was determined by (1) physical aspects such as climatology and soil characteristics, water resources availability and origin, (2) private or public irrigation scheme initiative, (3) structure of the irrigation system, (4) socioeconomic aspects such as age and education of farmers, attitude of community leaders, corporate culture, and sociological characteristics. In the case of groundwater the bulk of irrigation has been promoted by private initiative, with a particular bearing on the cost of the exploitation. This marks c clear difference between surface and groundwater irrigation communities, whereas surface water irrigation communities where almost exclusively created by state initiative, in the case of groundwater it was in many cases user led. For example, in Andalusia of the inventoried area which is irrigated thanks to groundwater around 19% is managed by collective organizations.

Groundwater user collectives or groups have emerged in the last four decades (the earliest in Delta del Loobegrat date to the 1960s). These groundwater use groups have emerged both as a management entity, and as a rent seeking group to defend their interests, which were affected with the changes to the water law (Gorostiza and Merino de Diego, 1998). Collective action by users has been effective as a management-or governance- entity in certain cases, especially when the resource entitlement or infrastructure belongs to the collective, an abstraction Plan has been developed in collaboration with users, and importantly, when higher level authorities such as the water boards recognize and support water user collectives and water rights (López Gunn and Martínez Cortina, 2006). Since this institutional and organizational diversity is complex, this study wanted to carry out an in-depth inductive study, some of these results are presented in this communication.

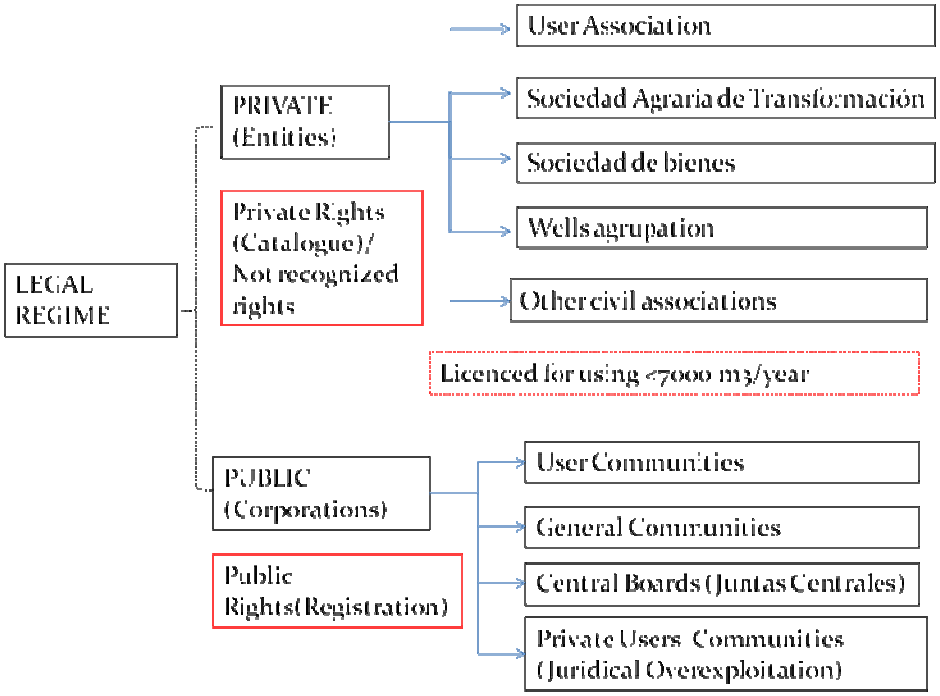

Figure 1-Diversity of Groundwater User Organizations (source: Rica et al. 2011)

CASE STUDY PRESENTATION AND METHODOLOGY

Three different subunits all located in the province of Almería were selected for the comparative study on the relationship between human-nature regarding collective action on groundwater management. . Data collection consisted on expert interviews from the three different sub-units, as well as two focus group with association representatives, in each subunit. This information analysis has been supported with an analysis of secondary sources such as official plans and reports, irrigation inventories, and press releases. These three areas share some similarities: like climatic conditions, groundwater as a key factor for the economic development of each region, based on exporting highly profitable greenhouse products; and where groundwater quantity and quality have been compromised at the expense of users and ecosystem. In general surface water bodies are seasonal and are heavily modified by human activity in the terminology used under the European Union Water Framework Directive. These groundwater bodies´ management and conservation are under responsibility of the Andalucian Government, with devolved powers from central government for basin management of the so called Mediterranean basins. According to the last characterization of water resources in the planning process, only 48% of total water resources are in a good state (Corominas 2010). The following section describes the sub-units from a SES perspective. It is necessary to clarify that the boundaries to these systems are partly constructed to be able to understand the issues at stake.

RESOURCE SYSTEMS AND ITS UNITS

The three groundwater bodies focus of this case study are called Campo de Dalías, Medio-Bajo Andarax, and Campo de Níjar (figure 2). The economic development in these areas was largely based on the silent revolution on groundwater use, for productive uses such as irrigation and also for drinking water supply for the population. However, water demand has grown at a higher rate than the available water resources, leading to situations of so called structural water deficit, which was made worse with the decrease in the quality of the available resources. Although on average conductivity values are higher in Campo de Níjar and in coastal areas, this deficit was present in all regions. To reduce that deficit the first option was individual or local community-based techniques by drilling deeper wells or intensifying the greenhouse activity. Secondly, collective action and the increase in knowledge on the aquifer and on water recycling and desalination techniques allowed the diversification of water resources.

Local scale distribution of water was not been studied in detail (work in progress), but it is thought to have a stake on users´ strategies to adapt their demand. Regional studies from the Spanish Geological Institute, *IGME* are assessing the locations that are more sensitive to salinisation if abstractions are undertaken in specific areas, with the purpose of a possible reallocation of wells in Campo de Dalías (Domínguez Prats and Franqueza, 2009). In this groundwater unit, water deficit is especially high in the lower aquifers which are of a better quality and store nore water, while upper layers are no longer being used causing waterlogging problems in certain areas. The main problems related to groundwater resources in Medio-Bajo Andarax are its unequal distribution and the bad quality (Sánchez-Martos et al 1998), something also present in Campo de Níjar. During fieldwork an exercise to detect these especially sensitive locations was done by different users from the three areas. The outcome of the exercise is that is that it is well known by local users where the good quality water is located as well as where the problematic wells are. However there is as yet no institutional arrangement to redistribute the good quality resources and stop abstracting in sensitive spots.

In Campo de Dalías, some user communities' representatives admitted to share water with the ones who had serious quality problems in other communities, selling "water turns" at the same price or at

a higher price, sometimes reinvesting the money on the community sometimes not, being a business for the water turn owner. This issue requires more attention, since it is an informal way of water redistribution, an informal water market.

	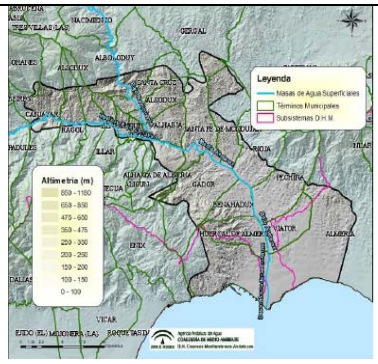	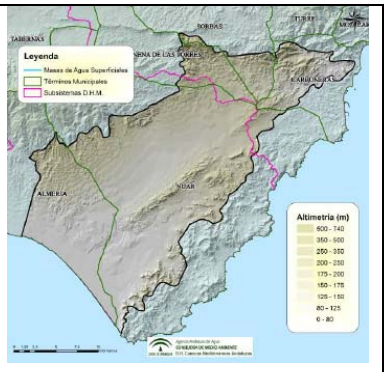
Campo de Dalías-Sierra de Gádor	Medio-Bajo Andarax	Campo de Níjar
797,09 km2 in surface	341,9 km2 in surface	466,15 km2 in surface
Declared over-exploited in 1986 and 1995 (no management plan) Bad global state, 2010 (WFD)	Declared over-exploited in lower areas in 1986/ (management plan in construction) Bad global state, 2010 (WFD)	Declared Overexploited (no management plan) Bad global state, 2010 (WFD)
- Pollution by nitrates from agricultural sources and phytosanitary products -Pollution by urban Wastewater -Pollution by industrial Waste - Over use, marine intrusion and other salination processes	- Pollution by nitrates from agricultural sources and phytosanitary products -Pollution by urban water waste -Over use, marine intrusion and other salination processes	-Pollution by nitrates from agricultural sources and phytosanitary products -Over use, marine intrusion and other salination processes
Mixed: carbonitic in mountains, Detritic in coast	Detritic Nature	Detritic Nature

Figure 2. Groundwater resources in case study areas. Source: own elaboration based on Agencia Andaluza del Agua

Other solutions to the water deficit in the areas were to recycle water or to desalinate. In Campo de Dalías there is a plan to diversify the origin of the water, although this has not been implemented yet and users are afraid of the cost that these new sources could suppose. One public WUA, Sol Poniente, receives water from a nearby reservoir-Benínar-, about 3-6 Mm3 per year. In Bajo Andarax, the WUA “Cuatro Vegas” has a license to use wastewater from Almería city, approximately 12 Mm3, for agricultural purposes. In 2009, 6,6 Mm3 of recycled water were delivered by this community, with a cost of 0,29-0,36 €/m3. In Campo de Níjar the alternative

resource is desalinated water from a plan in Carboneras. This is the biggest desalination plant in Europe, with a capacity to generate 42 Mm3/year of water. However, it has never been used to its full potential and yield. The plant and the distribution network were built mostly with public investment, and users are responsible for the water delivery and management. The desalination plant was built for the purpose of reducing the pressure from using the bad quality aquifer, as a measure to preserve the lower aquifer while maintaining the relevant economic activity in the area. Field work established that at present a plan does no exist to regulate the use and abstraction as well as the need for alternative sources. Users ask for the desalinated water they consider they need, and then the water is mixed with groundwater from the aquifer. What seems to determine the amount of water used from each source is the price of each source, and the quality needed for the activity. The cost of desalinated water is 0,48 €/m3, against the 0,25€/m3 cost of groundwater pumping. It is possible that the water price is the reason why the desalination plant of Almería, which is supposed to bring 30 Mm3 of water into use, is not working and thus not providing substitute resources to aquifer users.

Taking into account the need to substitute the use of groundwater resources under stress with other supplies to cope with demand, we could argue that this social ecological system is not robust. However, it seems that the social subunit is more robust than the ecological one, which needs to be adapted to the demand.

GOVERNANCE ARRANGEMENTS AND USERS

Almería is the most productive agrarian province of Spain. To understand this position it is necessary to take a look at the past. The existence of collectives managing water from wells has also its roots in the past. The agrarian policy after the civil war from 1939 was a determining factor for the establishment of agriculture in Almería. Irrigation districts were designed by the *Instituto Nacional de Colonización (INC),* whose objective was to support rural development through irrigation projects. In 1971 the INC became the *Instituto de Reforma y Desarrollo Agrario* (*IRYDA)*, and in 1984 in Andalucia itself this was named the *Instituto Andaluz de Reforma Agraria (IARA)*. In Almería, settlers were established in certain areas, particularly in Campo de Dalías, Campo de Níjar and Huércal-Overa. Technicians from these agrarian reform institutes researched on greenhouse technology on artificial soil to improve land productivity, and the transformation started (Rivera, 2000). Irrigator communities had different ways to emerge. The first case was the irrigation districts designed by INC, whose management was then transferred to its users. For example, in Campo de Dalías a number of wells provided groundwater to six irrigation sectors. Land plots were linked to a certain well.

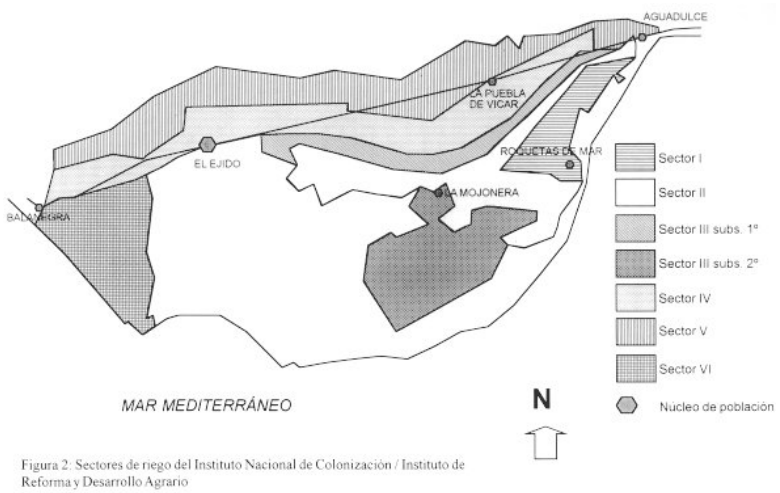

Figura 2: Sectores de riego del Instituto Nacional de Colonización / Instituto de Reforma y Desarrollo Agrario

Figure 3. Irrigation sectors designed by the National Colonization Institute (source: López-Gálvez and Losada, 2001)

This initiative was copied by the rest of the population, who either joined their resources or efforts to build a well together to irrigate their land (Cuadrado, personal communication), or bought a small plot from big land owners who sold their hours from the well to land tenants (Jiménez, personal communication). These initiatives ended up in a *Sociedades de Bienes* or *Sociedades Agrarias de Transformación*, a formal associative figure to regularise the situation of water sharing and land using under private law.

In the three case subunits, farmers, municipalities and industries demand water. What are the governance arrangements to regulate water use? In Andalucia, a new water law has been adopted from 2010, which is an attempt to combine the current Spanish water law from 1985 and the Water Framework Directive, as well as incorporating many elements from a new Water law that wa almost approved in 2008. Without going into detail on the changes and novelties this regional law is introducing, the most important aspect for this paper is the mandatory constitution of Groundwater User Communities (*Comunidad de Usuarios de Masas de Aguas Subterráneas, CUMAS*) in the same groundwater body to analyze certain aspects of these bodies:

- Only public water right holders could organize in CUMAS, but it is not mentioned whether private water rights are included
- It contemplates situations where several CUMAS, individual users and other type of users share the same aquifer-what turns out to be the reality in most groundwater bodies-. The associative figure in this case is the *Junta Central de Usuarios.* Agriculture, water supply, industry, tourism and other economic activities can be represented under this figure, which can have the function of coordinating the use and controlling, and defending its users´ rights and interests. Private right holders have the possibility to join in this type of organization.
- This organizations must be created in all the groundwater bodies characterized as having a poor global status, such as the subunits we are studying.

If one looks at the Spanish 1985 Water Act, not much difference is found in regard to what is established for overexploited aquifers, except for the updated terminology. On the other hand, we have seen that the trend now is to use multiple water resources as a way to reduce the pressure over groundwater resources, then, why sectorializing collective action on the water origin? In Júcar basin, Juntas Centrales are by norm responsible for groundwater and surface water, acknowledging the use of both resources. Let us take a look to what is happening in the three case sub-units in Almería.

ORGANIZATION AROUND THE RESOURCES: COLLECTIVE ACTION IN ACTION

The section above discussed the origin of the water users in Almería, this section will analyze the current organization around the resources in each region. Despite being “democratic” entities, where participation by users can be realized if users have an interest, and generally “one person one vote” applies, the territorial or decision-making scope can be limited. This can have negative consequences for the whole range of users if actions are not coordinated at a larger scale including all groundwater unit users.

Campo de Níjar

In this region, groundwater and desalinated water are the main available sources. Irrigation is the main demand, and most farmers, approximately 2247 against 487 individual users (Junta de Andalucia, 2008) are organized in User Organizations; this does not onclude the non reported individual wells that members can have drilled. Each GWUA manages its own well or wells, without a volumetric limit. *Sociedades de Bienes* and *SAT* are the associative figures chose by users, since these farmenrs don ot have public rights.

A new Water User Community, *Comunidad de Usuarios del Campo de Níjar (CUCN)* was created to manage desalinated water for irrigation from the desalination plant constructed. This is a public corporation in charge of delivering desalinated water, regulated by users. It is important to mention that farmers from Campo de Níjar had a crucial stake in the construction of the desalinated plant, since there was a collective common effort to demand water from an alternative source to the aquifers. There is no coordination of water use, and despite knowledge on the behaviour and state of groundwater bodies behaviour and a formal legal declaration of aquifer overuse overexploited, there is not a Plan to control abstractions yet.

Medio Bajo Andarax
If there is something that can be said about this region is its diversity, in aspects such as geography, landscape and agrarian production. Regarding this last issue, groundwater may be more associated with the production of horticultural products in the other regions, but in this subunit it is also common to irrigate fruit trees, olive and cytric fuit trees.

Irrigation communities are also more common than individual users, and it is estimated that there can be around 16 private entities, using around 2900 ha and integrating 4000 members. From this data it is possible to interpret that plots in general are small. Besides these small communities that use groundwater, there is one community important for the research, *Las Cuatro Vegas de Almería.* This is the community responsible for the tertiary treatment by ozone of the wastewater coming from the city of Almería, and for the delivery of the recycled water among the users that wanted to join the community. Similarly to what happens in *CUCN,* members are not obliged to use recycled water, and the use of recycled water does not mean that water from the aquifer is not being used. Overall the balance is positive with an average use of 6,6 Mm3 per year. In wet years, this amount however decreases. The price of this water is not much higher than the price of pumping groundwater, and is around 0,29-0,36 €, is still more expensive than surface water.

A number of years ago, the Andalucian water administration took the initiative to lead a participatory process with the purpose of creating a *Junta Central de Usuarios* and elaborate a management plan for the groundwater body where users were involved. In 2010 the new *Junta Central de Usuarios del Medio-Bajo Andarax* was constituted as a public corporation, including the main WUAs, municipalities, industries and individual users. The challenge now is to develop a plan that is able to reduce pressure on the aquifer while maintaining the economic activities. It is expected to be on a good track. A first approach to its success has been the inventory and process of regulation of private water rights, crucial step into any plan of water reallocation (Crespo, personal communication)

Campo de Dalías-Sierra de Gádor
Because of its big extension and productivity, this may be the most popular case. Besides holding a population that demands around 17% of current available resources, there is a big number of farmers organized in WUAs. Besides two organizations that receive water from the reservoir and therefore are public corporation entities, the rest are a mix of private entities, *Sociedades de Bienes*, called erroneously irrigation communities, and *SAT*. According to the regional irrigation inventory of Andalucia, there are more than 40 GWUAs, in a surface of about 18500 ha of greenhouses.

In Campo de Dalías-Sierra de Gádor we have the evidence that water is as essential for life and productive activities as contested as a Resource. In 1986 the first legal restrictions appeared in the region, and the aquifer was declared over exploited in 1995. However, there is no abstraction plan for the groundwater body and there is not even an organization that integrates the whole range of users. This sounds paradoxical if we take into account that there is already a Central Board of Users, *Junta Central de Usuarios del Poniente Almeriense*, public corporation constituted in 1991. It includes 7 municipalities, 3 industries, 38 irrigation communities or GWUAs and around 118 individual users, and was created by users initiative. The truth is that there is a parallel organization, *Comunidad de Usuarios del acuífero Sierra de Gádor*, which is also a public corporation entity composed by different GWUAs, who refuses to take part in the JCUAPA as a General Community.

It has been difficult to determine how many GWUAs compose the General Community of Sierra de Gádor since in 2008 it has had internal problems, but users share the same groundwater resources with the members of JCUAPA, especially now that the groundwater body limits are defined and the aquifer layers well known by hydrogeologists. JCUAPA holds water rights over the excess water from Benínar reservoir. However, due to water loss in the reservoir structure and demands from other users, it is not usual for this organization to receive water from the reservoir (Poveda, personal communication).

What is most interesting is that the more obvious collective action has not been water but energy. Collective action efforts have been directed to the lowering of electricity for the sector in Campo de Dalías. Concerned by the high price users must face to pump groundwater, some users of JCUAPA and other electricity users such as touristic resorts have changed the electricity supplier, now that the energy market in Spain has been liberalised, and users have joined together to negotiate prices with electricity companies. This action has been lead by the secretary of the organization, whose input has been crucial for its success. It is known that leadership is an important factor in most collective action, since they can empower and encourage people, and facilitate processes.

FINAL REMARKS

What kind of incentives to "preserve" a resource, or in other words to maintain the resilience of the social ecological system, can there be if additional water sources are brought into action without the proper groundwater management plan? The current model of a community delivering desalinated sea water on demand of the user in Campo de Níjar seems to be an effective measure to continue with agrarian activity, but does not necessarily mean that the quantitative and qualitative status of the aquifer is going to improve because groundwater supplies are not managed collectively, but instead by different organizations, municipalities and individuals. The desalination plant might be more desirable than the multiple uncontrolled small groundwater desalination machines, which, besides causing pollution problems with its waste, also contribute to the uncontrolled use of the resource.

The rate of abstraction and quality impoverishment has caused that users with access to better technologies could use the resource where it had better conditions for the activity for which it was demanded. Therefore, it is believed that the location of wells on "luckier" areas and private individual initiatives on improvements of technology has been a determinant factor in the "natural selection" of users, against a collective action of users to preserve the resource that is coming later in an attempt to adapt the management in a more equitable way.

In the three areas, three different strategies have emerged to maintain the social resilience of the system, and all of them have been carried out in a collective way. Actions towards a decrease in energy price, use of alternative sources such as recycled water or desalination were encouraged by certain users, with notable leadership skills, and followed by a majority of users. In the case of Campo de Níjar public funds were crucial for the desalination plant installation. The common goal coincided with the individual interest

However, it is important to mention that the resilience of the social subunit of the system may not go hand in hand with the resilience of the ecosystem subunit. It may be contradictory with the definition of social ecological system, but it seems that at certain scales it happens that the equilibrium among subunits is not stable. There is a moment when the ecological subunit cannot stand the disturbance but the social subunit draws upon external resources in order to keep resilient. In other words, the "social subunit" breaks the dependency interaction with groundwater resource. For research matters, this statement is taken as result and at the same time as a working hypothesis emergent from inductive fieldwork.

To finish, and in relation to globalization, maybe it is important to keep in mind that most produce from the production from this region is meant for exports, and how this area is knowns as "the

orchard of Europe". Therefore, one of the main drivers for the collective action initiatives to maintain the "resilience" of the social subunit just presented in this communication goes beyond the boundaries of the country, constituting itself as a possible external disturbance to the social ecological system as a whole.

BIBLIOGRAPHY

Anderies, J.M., Janssen, M.A. & Ostrom, E., 2004. A Framework to Analyze the Robustness of Social-ecological Systems from an Institutional Perspective. *Ecology And Society*, 9(1).

Becker, Egon (2010): Social-ecological systems as epistemic objects. Institute for Social-Ecological Research (ISOE), Frankfurt/Main, forthcoming. AVAILABLE AT: http://www.isoe.de/ftp/publikationen/eb_socecsystem2010.pdf

Corominas (2010) Los Nuevos Planes Hidrológicos de las Cuencas Andaluzas, in *2nd National Seminar of Botín Foundation´s Water Observatory "The role of groundwater in Spanish policy",* Madrid

Domínguez Prats, P. and Franqueza Montes, P., (2009) *La investigación de los acuíferos en apoyo a la mejor gestión de los mismos: la experiencia del Instituto Geológico y Minero de España con los acuíferos del Poniente almeriense,* in Jornadas AEUAS "Los Usuarios y la Protección y Recuperación de las Masas de Agua Subterránea", Almería 29-30 Octubre 2009. Available at: http://www.aeuas.org/resources/pdf/almeria/A4-IGME-P%20Dominguez.pdf

Holling, C. S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*4:1-23.

Junta de Andalucía (2008) Inventario y caracterización de los regadíos de Andalucía. Distritos Mediterráneos y Atlánticos. Actualización 2008

Junta de Andalucia, (2007) *Special Plan for Drought in mediterranean andalusian basins.*

Llamas, M.R. & Martínez-Santos, P., 2005. Intensive Groundwater Use: Silent Revolution and Potential Source of Social Conflicts. *Journal of Water Resources Planning and Management*, 131(5), p.337. Available at: http://link.aip.org/link/JWRMD5/v131/i5/p337/s1&Agg=doi.

López-Gálvez, J. & Losada Villasante, A., 2001. La gestión del agua de riego en el campo de Dalías. In *La economía del agua subterránea y su gestión colectiva.* Madrid: Fundación Marcelino Botín y Ediciones Mundi-Prensa.

Lopez-Gunn, E. & Martinez Cortina, L., 2006. Is self-regulation a myth? Case study on Spanish groundwater user associations and the role of higher-level authorities. *Hydrogeology Journal*, 14(3), pp.361-379. Available at: http://www.springerlink.com/index/10.1007/s10040-005-0014-z.

Ostrom, E., 1990. *Governing the Commons*, Cambridge University Press.

Ostrom, E., 1998. A behavioral approach to the rational choice theory of collective action. *The American Political Science Review*, 92(1), pp.1-22.

Rivera Menéndez, J., (2000) Agrarian Colonization Policy in Campo de Dalías (1940-1990), *Instituto de Estudios Almerienses*, Cajamar, Almería

Ramos Gorostiza, J. L y A. Merino de Diego. (1998). Las comunidades de regantes y la nueva política del agua: los problemas de la acción colectiva. In *I Congreso Ibérico sobre Gestión y Planificación del Agua*, Zaragoza.

Sánchez Martos, F., Pulido Bosch, A., Calaforra, J.M. y Navarrete, F. (1998) *Algunos aspectos de los usos del agua en el Bajo Andarax.*in I Congreso Ibérico sobre Gestión y Planificación de Agua, Zaragoza. Available at: http://grupo.us.es/ciberico/archivos_acrobat/zaracomun2sanchezmar.pdf

Valero de Palma J., (2011), *Posibles soluciones al pequeño tamaño de las comunidades de regantes en España,* in 4th national seminar of the Water Observatory of the Botin Foundation "Los Retos Institucionales de la Gestión Colectiva del agua subterránea", Madrid. Available at: http://www.fundacionbotin.org/4-seminario-nacional-gestion-colectiva-aguas-subterraneas_observatorio-del-agua_actividades.htm

Van Vugt, M., 2002. Central, Individual, or Collective Control?: Social Dilemma Strategies for Natural Resource Management. *American Behavioral Scientist*, 45(5), pp.783-800. Available at: http://abs.sagepub.com/cgi/doi/10.1177/0002764202045005004.