Decentralization and economic incentives to manage groundwater withdrawals for irrigation: from theory to practice

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Decentralization and Economic Incentives to Manage Groundwater Withdrawals for Irrigation: from Theory to Practice

A.-G. Figureau[1,2], M. Montginoul[1] and J.-D. Rinaudo[2]

[1] Institut de Recherche en Sciences et Technologies de l'Environnement et de l'Agriculture, 361 rue Jean-François Breton, BP5095, 34196 Montpellier Cedex 5

[2] Bureau de Recherches Géologiques et Minières, 1039 rue de Pinville, 34000 Montpellier

Abstract. France is currently embarking upon a drastic reform of quantitative water resources management. This reform relies on two principles: the definition of an upper limit to water abstraction per water body and the decentralization of the responsibility for allocating water among users, in particular in the agricultural sector. This paper looks at possible institutional arrangements and incentive-based economic instruments which could be used to implement this reform. It particularly focuses on issues and options related to the enforcement of water allocation within the agricultural sector. We present three water management scenarios relying on four levers: economic incentives, transparency, negotiation, joint liability. Scenarios were evaluated through 16 scenario workshops in five French case studies, gathering 124 farmers and agricultural stakeholders in total. This paper presents the results of the workshops through a semi-quantitative analysis of the arguments given by the participants.

1 Introduction

In France, as in many other EU countries, groundwater development has occurred in an institutional setting that imposed few if any limits on groundwater use. For want of time, money and personnel, state services cannot ensure that all wells are notified and authorized discharges are complied with. In several parts of France, this has resulted in declining water tables, with significant impacts on dependent rivers and ecosystems.

Until the mid-1990's, local authorities reacted by establishing water restriction rules (irrigation bans). According to the French Water Law of

2006[1], this crisis management system must now be replaced by a structural approach based on a quota system. In aquifers considered at risk for over-exploitation, hydrogeological studies are conducted to assess the total maximum volume that can be abstracted. This volume is then shared among users. Where over-exploitation is the result of intense irrigation use, a local Groundwater User Association –GWUA- (*Organisme Unique de Gestion Collective* in French) must be established. GWUAs are in charge of apportioning among farmers the amount of water allocated to the irrigated agriculture. This context typically reflects the public policy transition described by Petit (Petit, 2004), who identifies a shift in paradigm from a dichotomous state or market regulation to one involving stakeholders and that relates to the notion of governance. How this new form of governance can be put in place remains an open issue. GWUAs can be considered as micro-institutions which are "inserted between global rules that circumscribe the environmental context on the one hand, and agents, organizations and contractual agreements they are tied with on the other hand[2]" (Ménard, 2003). Such intermediary institutions adapt general institutional rules to effective local organizations and allow transaction costs to be reduced. As to groundwater, it is assumed that a locally-designed institution will be more efficient than the government at enforcing a groundwater quota system.

Our work was conducted in this context. It aims at exploring how economic tools can be used by the newly established GWUAs to ensure compliance with allocated volumes. Such tools are intended to counterbalance farmers' propensity to exceed their quota in order to cope with climate variability and other sources of environmental and economic uncertainties. This is typically an enforcement problem which we are tackling in this paper.

The literature abounds in propositions concerning economic incentives to solve similar common-pool resource (CPR) problems. Our work fits into this literature that analyses the link between management tools and the institutional context. Through detailed case studies, tools for CPR management are analyzed, explicitly looking at the place they occupy in a broader institutional pattern. This helps in analyzing the factors that determine the effectiveness, practical feasibility and social acceptability of the economic instruments.

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[1] Loi n° 2006-1772 du 30 décembre 2006 sur l'eau et les milieux aquatiques *Journal Officiel de la République Française*, n°303 du 31 décembre 2006

[2] Ménard C., 2003, "L'approche néo-institutionnelle : des concepts, une méthode, des
[2] Ménard C., 2003, "L'approche néo-institutionnelle : des concepts, une méthode, des résultats", *Cahiers d'Economie Politique*, 44, p.114

One of the innovations of the paper is to examine tools that could be implemented in the future, in a context of groundwater policy reform. Unlike most studies which conduct ex-post analysis of factors determining the effectiveness of CPR management instruments, we adopt a participatory foresight approach aimed at designing instruments for the 2020-2030 timeframe. This approach is deployed in five French case studies representative of the diversity of hydrogeological and agricultural conditions.

The paper is structured as follows. In the next section, we present a framework to analyze alternative decentralized groundwater management institutional setups. We use this framework to design three decentralized groundwater management institutional scenarios which are subsequently debated with stakeholders. These three scenarios are presented in the third section, which also describes the methodology deployed to evaluate the scenarios with stakeholders and briefly presents the case studies. The fourth section presents the results obtained, highlighting the advantages, disadvantages, limitations, conditions and risks involved with the instruments considered.

2 Theoretical concepts and associated literature

2.1 Conceptual framework

The objective of the work presented in this paper is to design and evaluate institutional scenarios for decentralizing groundwater management. Decentralization is understood here as a partial withdrawal of the State and a transfer of its responsibilities to users, represented by an intermediary institution designated, in the remainder of this paper, as GWUA. Each scenario defines a micro-institution which ensures a number of processes. These processes can be organized in various ways, and each particular decentralized groundwater management set-up consists of a unique mix of these (Figure 1).

The "*external interaction*" process defines the State-GWUA relationship. It is designed to ensure that the total groundwater volume allocated to the GWUA is complied with.

The five other processes are intended to regulate the relationship between the GWUA and the individual farmers. The "*decision-making*" process is characterized by who the decision-makers are (all members, elected representatives, wise persons,…), the decision-making mode (majority vote or consensus, consultative participation of members,…) and the scope of the

decision. We consider here that decisions deal solely with water allocation and the incentives to be implemented.

The "*financing*" process corresponds to how the GWUA's operating costs are covered. This relates to fees that can be charged to users and to expenditures and investment planning.

The "*water allocation*" process consists of rules that set the amount of water each farmer is entitled to. It may also define how this allocation may be modulated notably via negotiations.

The "*enforcement*" process consists in providing farmers with incentives for complying with their water entitlements. This process may rely on a system of random controls and fines, subsidies or taxes, transparency and social control, etc.

The "*conflict resolution*" process refers to routine discussions or forums that reduce tensions, but also to the GWUA's capability to resolve exceptional disputes between users by means of a justice-like power. It also defines how to deal with farmers who refuse to comply with decisions taken by the GWUA.

This paper focuses on the enforcement process. It investigates how different tools can be combined to increase the probability that agricultural groundwater users do comply with the allocation rules. Several instruments are considered, in particular financial incentives and increased transparency. We also investigate how enforcement can be improved by changing allocation rules, for instance through allowing farmers to renegotiate their initial allocation within small groups.

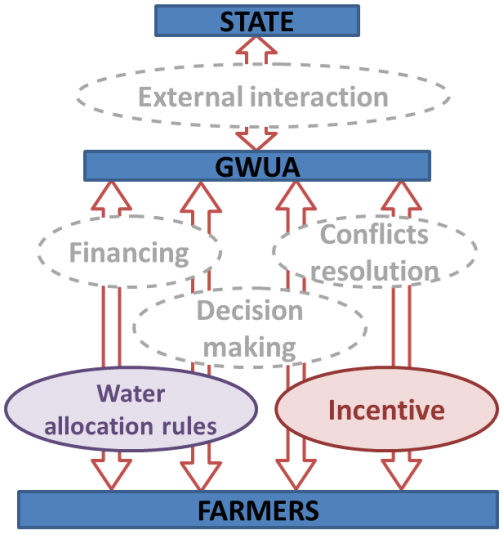

Fig. 1. Main processes performed by a micro-institution ensuring decentralized groundwater management. Subsystems enclosed in dotted lines remain unchanged in our scenarios.

2.2 Four levers for improving water allocation enforcement in a decentralized scheme

In this paper, we will be considering four main levers that can be activated by a local organization in charge of apportioning a natural resource (groundwater, in our case):

- *Economic incentives*, intended to promote users' decisions compatible with the targeted apportionment plan or discourage free-riding behaviors; including payments that reward desirable behaviors and penalties that sanction free-riding ones.
- *Negotiation*, which intends to increase flexibility, allowing temporary reallocation among users; it can be allowed on a bilateral or multilateral basis, and can occur within predefined groups or in the community as a whole, under supervision by the GWUA.
- *Transparency*, which consists in publicizing information on individuals' withdrawals, assuming that the social pressure exerted by others will make free-riding behavior socially costly.
- *Group responsibility*, which consists in allocating water to groups of users and empowering them to apportion their collective entitlement among themselves.

This section conducts a succinct overview of the literature concerning these four levers.

- **Economic incentives**

The effects of monetary sanctions or rewards on the behaviour of agents confronted with a problem of collective action have been widely studied, mobilising micro-economic modelling and experimental economics approaches. These studies demonstrate the effectiveness of these tools (d'Adda, 2011; del Pilar Moreno-Sánchez and Maldonado, 2010; Fehr and Gächter, 2000; Masclet, et al., 2003; Rapoport and Au, 2001; Sefton, et al., 2007; Travers, et al., 2011). The impact of using reward alone seems less efficient (Rapoport and Au, 2001) and less durable over time (Sefton, et al., 2007). However, it sometimes turns out to be more effective than sanctioning (Travers, et al., 2011). Sefton et al. (2007) propose to couple these two forms of incentives which, in their case, have enabled optimum levels of individual contribution to be achieved.

The efficiency of these tools depends on their design. The level of the incentive is a determining factor. A sanction should be severe enough to provide incentive and moderate enough to be economically and politically acceptable. The regulatory authority is also a decisive factor: tested in experimental economics, regulation exerted from the inside appears to yield better results than regulation imposed by an outside player (Travers and al., 2011; del Pilar-Moreno-Sanchez and Maldonado, 2010). Efficiency will differ according to whether it is lump-sum or proportional to the discrepancy between the prescribed behaviour and the one actually observed. Another important dissuasive factor lies in the probability of incurring the sanction (Murphy and Cardenas, 2004) which, if not high enough, is liable to cancel out its incentive impact.

Rapoport and Au (2001) bring up the issue of funding the incentive mechanisms and cite the advantage of a system that allows the rewards to be covered by the revenue from the penalties. While it has also been discussed by Collins and Maille (Collins and Maille, 2011), this system of compensation between penalty and reward has never actually been put to the test.

The variable nature of these results, which prevents us from generalizing their main conclusions, can be imputed, on the one hand, to the diversity of the contexts and how the experimental assessment system was designed and, on the other hand, to the specification itself of these tools. This recognized variability in results justifies the multiple terrains and contexts that have been chosen to test these tools.

- **Negotiation**

The second lever examined is negotiation. The groundwater demand for farmers is liable to vary substantially from one year to the next, owing to changes in the choice of crops or external disruptive factors. Complying with an unvarying allocation may represent a very stringent constraint for farmers and give rise to enforcement problems. In this context, allowing farmers to negotiate with each other injects a degree of flexibility which may allow an overall compliance to be achieved.

This approach involving agreed upon rules or arrangements has proven relatively advantageous for controlling over-abstraction of a resource held in common, and this is true of numerous and contrasting contexts ((Lopez-Gunn, 2003; Ostrom, 2000; Shah, 2012; VanSteenbergen, 2006). Its efficiency, as compared to external regulatory systems and economic incentives, has been demonstrated in many contexts (Travers et al., 2011; del Pilar-Moreno-Sanchez and Maldonado, 2010 and Murphy and Cardenas, 2004). However, it can only be of benefit if a certain number of conditions are met: a detailed knowledge of external factors, an awareness of players' interdependence, a quantified assessment of profits dependent on the action of others (Murphy and Cardenas, 2004) and previous acquaintance among players (Cardenas, 2004).

- **Transparency**

The third lever is transparency, that is, the disclosure of the decisions or individual actions of agents to all members of the concerned community. Such a tool has been tested in experimental economics for a variety of scenarios and its positive effects on behavior was demonstrated repeatedly (Masclet et al., 2003; Fehr and Gatcher, 2000). It is sometimes shown to be more effective than a penalty (Foulon, et al., 2002). It is often advocated as an auxiliary management tool, its main advantage being its very favorable cost-benefit ratio. However, some studies would indicate that its effect varies from one community to another, being conditioned by the prior existence of a norm defining what constitutes virtuous behavior (d'Adda, 2011; Travers et al., 2011). Its effectiveness likewise depends on the weight carried by reputation. Transparency may take on a variety of forms according to whether individual or collective behaviors are being disclosed, and whether by name or anonymously.

The main risk attaching to this tool is the emergence and propagation of a weak or even counterproductive social norm (mediocre contributions, to the common good, widespread over-exploitation…) which may result in a race to the bottom (Zafar, 2011).

- **Joint liability**

Irrigators are a special class of groundwater user insofar as they constitute a professional corporate body that shares information among its members, communicating with each other about their practices and having experimented at times with collective management (with the example of collective management of farm equipment via CUMA[3] groups). For this reason, allocating a volume to a group that is collectively responsible emerges as a means to provide flexibility while at the same time guaranteeing compliance with the volume authorized.

Studies on group dynamics have been developed on the premise that the agents have more information on their reciprocal actions than the controller or principal. (Isik and Sohngen, 2003; Romstad, 2003) Isik and Sohngen (2003) built a group contract model relative to a diffuse pollution context, integrating the social control factor, which is shown to be essential in order for the model to be effective. This contract is based on (i) performance, i.e., an obligation of results as opposed to means, (ii) voluntary participation (iii) a flat-rate payment by way of incentive to adhere to the contract and (iv) a performance-related payment as incentive to abide by the contract.

Finally, in our context of decentralized management as embodied by GWUA, our contract adopts the "nested enterprise" principle developed by Ostrom (Ostrom, 2000), which relies on nested self-regulation, accountability of the groundwater users and reinforced social control.

3 Scenarios for decentralized groundwater management in France

This section presents three scenarios of micro-institutions that could be implemented to solve the groundwater allocation enforcement problem described above. We start with a description of the current institutional set-up which regulates access to and allocation of groundwater in France. Next, we describe the institutional changes that are slated to occur by 2020. Three contrasting scenarios are subsequently delineated. We then describe the methodology used to discuss these scenarios with stakeholders in five different regions of France.

[3] Coopérative d'Utilisation du Matériel Agricole

3.1. The current context and possible evolution

Following the promulgation of the 2006 Water Law, groundwater management is undergoing drastic institutional changes in France. Prior to the reform, access to – and use of – groundwater was regulated by local governmental agencies. Agencies grant licenses to the owners of wells and boreholes, specifying the maximum discharge and, in water-scarce areas, the maximum volume of water that can be pumped. Decisions on volume allocation are made by governmental agencies after consultation of the Chamber of Agriculture. The State has sole responsibility for enforcing water allocation, although it lacks the human and financial resources to conduct the required controls. Conflict resolution relies fully on judicial procedures, but court cases are often abandoned and penalties charged to offenders are generally not dissuasive.

The 2006 Water Law introduces major changes in this institutional set-up. It requires that Ground Water Users Associations be established in all basins identified as over-exploited. These associations will be responsible for sharing between farmers the maximum volume that can be abstracted. Allocation rules can thus be crafted by this new micro-institution, in a decentralized decision-making framework that gives much more autonomy to farmers than previously. GWUAs will also be more significantly involved in conflict resolution and will have the possibility to design new instruments to ensure that their members comply with the allocation rules. How this can be done remains an open issue. The scenarios that follow intend to unfold three possible ways of addressing this challenge within the 2020-2030 timeframe.

In order to design the foresight scenarios, three main assumptions were made as to the most plausible future evolution of the institutional context, in continuation of the reform initiated by the 2006 Water Law.

- The first assumption is that the legal status of the GWUAs will be reinforced, providing them with a clear legal framework for crafting water allocation rules, enforcement mechanisms and conflict resolution procedures. GWUA will most likely be allowed to levy fees to cover their operational costs.
- A second assumption is that each farmer will receive an individual water entitlement that will be valid for a specific period of time (15 years). Individual allocations are assumed to be based (i) on historical records of water use and (ii) on an analysis of actual water demand, considering the assets and crop specialization of each farm.
- We further assumed that access to information related to groundwater use will be facilitated by changing technologies. Smart meters, already widely used in urban areas, are likely to be adopted in agriculture,

allowing accurate monitoring of pumping in all wells, with a daily, if not hourly, time-step. This information can easily be made available to selected beneficiaries via the Internet, including government agencies and the GWUA.

3.2. Negotiation and transparency

The first scenario combines two instruments:

- Transparency: we assume that information on individual withdrawal is made available not only to government agencies and to the GWUA, but also toall members of the GWUA. The underlying hypothesis is that this enhanced transparency will increase incentives for farmers to comply with the allocation rules, their individual behavior being observable by their peers.
- Negotiation: GWUAs offer a suitable context that allows farmers to adjust their individual allocations via bilateral or multilateral negotiations with other farmers. Indeed, farmers need flexibility if they are to adapt to unforeseen events. In this scenario, we assume that the required flexibility is made possible through a negotiation to be held pre-season and under strict supervision by the GWUA.

3.3. Combining positive and negative incentives to enforce water allocation: the payment-penalty system (P&P)

This scenario assumes that the best way to enforce water allocation rules is to provide users with strong economic incentives. We propose to use positive and negative incentives simultaneously, as suggested by Sefton et al. (2007). Negative incentives consist in sanctioning farmers who use more water than what they are entitled to. The sanction consists of a fine which is charged for each cubic meter pumped in excess of the limit. This sanction could be progressive. The sums recovered would in turn be used to subsidized farmers using less than their water entitlement. This subsidy would be granted proportionally to the volume of water "saved". The amount of the subsidy, expressed in €/m^3 saved, would depend directly on the number of farmers infringing their quota in the same year. . While the fine level would remain stable over a period of years, the subsidy would vary considerably over time. It would be low in wet years, as few farmers would pay a fine and high during dry years, when many farmers infringe on their quota, providing real incentives for other farmers to reduce irrigation. Overall, the proposed instrument should converge towards a simultaneous water and financial equilibrium. The financial dependence between farmers who save water and those who withdraw too much enhances the probability of sanction

application. Finally, the system should be acceptable to farmers for two reasons: sanctions are applied by peers, and money does not exit the agricultural sector.

3.4. The joint liability scenario

The last scenario proposes to create user groups, to merge their individual water entitlement into a group entitlement and make them jointly liable vis-à-vis the GWUA. Users groups are established on a voluntary basis, and their joint liability is formalized in a legally binding contract. Farmers gain two benefits from entering a group: reduced fees paid to the GWUA, and increased flexibility concerning water use (since they can make any arrangements concerning water use they wish with farmers of their group). If the group exceeds its water entitlement, the fine is doubled as compared to what individual farmers are charged. The group is jointly liable for paying the fine. For groups, as for individuals, the fine is charged proportionally to the excess pumping. This scenario assumes that joint liability will reinforce individual responsibility cooperation between members to reallocate water in an optimal manner, and is better able to factor in unforeseen events that may occur during the season. Group members have access to detailed information on volumes abstracted by each well of the group (combined use of smart meters and a web-based information system), which allows a mutual control within the group.

The three scenarios are summarized in Table 1, below.

Table 1. Main assumptions in the three scenarios

<table>
<tr><th></th><th>Consultation & transparency</th><th>P&P</th><th>Joint liability</th></tr>
<tr><td>External interactions</td><td colspan="3">GWUA is responsible vis-à-vis the State for compliance with the maximum abstractable volume</td></tr>
<tr><td>Financing</td><td colspan="3">GWUA levies fees from farmers and receives public subsidies from the River Basin Agency</td></tr>
<tr><td>Conflict resolution</td><td colspan="3">Routine discussions. Possibility for the GWUA to exclude members not complying with its rules. Government agencies then have the possibility to cancel the groundwater-use licence</td></tr>
<tr><td>Decision-making</td><td colspan="3">Key rules established by all members of the GWUA through a voting procedure</td></tr>
<tr><td rowspan="2">Water allocation rules</td><td colspan="3">Individual water entitlements established for 15 years, based on historical use of water, irrigated area and soil type</td></tr>
<tr><td>Temporary adjustments in water allocation possible through bilateral / multilateral negotiations between farmers</td><td></td><td>Individual entitlements merged for farmers signing a contract</td></tr>
<tr><td rowspan="2">Enforcement</td><td rowspan="2">Transparency</td><td rowspan="2">P&P</td><td>For individual members: fine</td></tr>
<tr><td>For group members: joint liability, fine, reduced fees</td></tr>
</table>

4 Methodology for evaluating scenarios

4.1 Methodology for debating scenarios with stakeholders

The theoretical scenarios dealt with above were presented and debated with stakeholders in five different regions in France, where the regulation of groundwater abstraction represents a real challenge. The objective was to identify factors which could impede (or facilitate) the implementation of the instruments described in the scenario.

A key assumption underlying our methodology is that the environmental and economic efficiency of the instruments considered may vary significantly depending on the hydrogeological, agricultural, economic and sociological

context. We further consider that stakeholders, including farmers, are able to identify these factors, which justifies involving them in the research process. We also assume that these factors may differ from one case study to another, which justifies consulting stakeholders in various contexts.

The method selected to involve stakeholders consists in organizing scenario workshops. A total of 16 workshops, mobilizing 124 participants, were organized in five selected case studies. The scenarios were adapted to each local context and presented as a short narrative, written as a press release. Participants were invited to think about their possible advantages and drawbacks, assuming they would be implemented from 2020 on. The workshops lasted four hours on average, and involved 6 to 15 participants.

Two types of participants were invited to take part: farmers (80), and official representatives of organizations involved in agricultural water management (44). These two categories were purposely divided into separate groups, given the high level of tension that existed between them.

4.2 Selected case studies

Five case studies were selected based on discussions with experts. All areas are ones where groundwater is officially considered as over-exploited. Stakeholders who were invited to participate in the scenario workshops were thus fully aware of the stakes and potentially interested in debating over possible instruments for regulating groundwater use.

Case studies were also selected in such a way as to represent a diversity of agricultural and hydrogeological situations. Groundwater characteristics vary significantly from one case to another in terms of geology (karstic or alluvial aquifer) and inertia (a few months to several years). Agricultural systems also differ, with industrial vegetable production in the Serre basin, apple and cereal production in the Tarn-et-Garonne, cereals and corn in the three others. The location of the case studies is depicted on a map below.

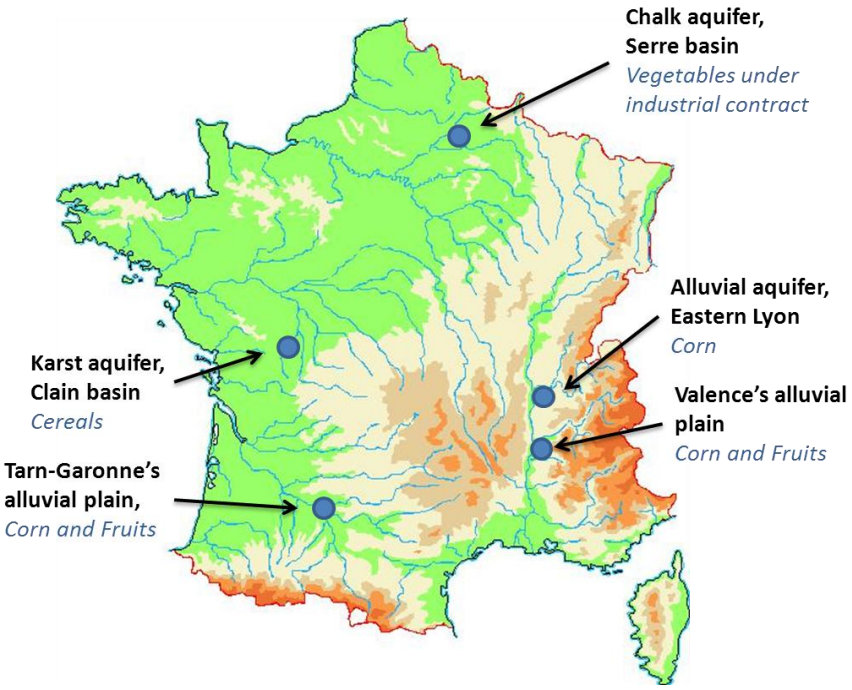

Fig. 2. Location of the five case studies in France

4.3 Quantitative treatment

Debates were tape-recorded to allow a detailed ex-post analysis of the arguments quoted by participants. These arguments were classified by type (advantages, drawbacks, risks involved or implementation condition), then by topic (injustice, incentive, legitimacy …), and finally by detailed argument. Preliminary quantitative treatment consists in arguments codification and frequency calculation. For ease of reading, we will only be specifying hereinafter in square brackets the number of workshops out of the 16 (or 13 for the first scenario) in which the argument arose at least once.

5 Results

Generally speaking, a certain number of arguments were mentioned in all scenarios or workshops. These elements related to the hypotheses of the future projected by the 2006 Water Law, which a majority of farmers disapprove, rather than scenarios mechanisms themselves. In particular, it is still very

difficult to discuss the matter of "quotas". Very reticent about this principle, irrigators insist upon the necessity of their being part of the process whereby such volumes are calculated, so that they are fair and acceptable. Moreover, these individual references must remain constant on a multi-annual basis to allow pluriannual investment decisions. They would not accept that such a system be applied to an abundant resource. Indeed, acknowledgement of over-exploitation of the groundwater resource is not shared by, and is even hotly contested by, the farming community. Once these conditions have been set, most farmers accept to project themselves into the proposed scenarios. They appreciate the main objectives: to render the strict quota system more flexible through reallocation mechanisms that allow the economic valorization of the total volume allocated to be maximized.

We will be presenting hereinafter the main reactions of the participants with respect to our three proposed management scenarios, highlighting for each the respective advantages, drawbacks, risks involved, and acceptable and effective implementation conditions.

5.1 Transparency

Transparency has given rise to sharply differentiated reactions.

For some, it is construed as the means to establish a true self-regulation of withdrawals [5] by irrigators insofar as it allows vigilant monitoring of both individual and collective abstractions [1]. It reinforces social control [4]. It has the potential to institutionalize social norms (relative to the periods of starting, stopping or resuming irrigation) and results in water savings: "*It is true that it may allow, when one is hesitant, to cancel the last irrigation turn.* The resource is also better allocated [4] owing to real-time adjustments, information on crop requirements (through how others act) [1], but also on assessing unused volumes [3].

Nevertheless, many question its legitimacy and acceptability [9]. It comes across as an infringement on individual liberties [4] and makes the assumption that farmers will not comply with their quotas [1]. This tool may fuel dissentions [5] since transparency leads to a form of self-police implying mechanisms decried by some ("denunciation", "policing") [6]: "creating problems where there aren't any", "causing tensions to mount", notably between adaptable crops and those with incompressible needs [1]. This tool would be neither advantageous [2] nor effective [2]: certain exceedances are voluntary and assumed by "hard-liners" who are already identified [1]; groundwater users will continue to save their crops in times of drought [2].

Some even cast doubt on the pertinence of the chosen indicator (the volume abstracted) [3]: a farmer's practices cannot be judged based on this sole

criterion. The measure of the effort should actually depend on the crops, the material, the time of year, possible leakage [2]... They accordingly favor the choice of a means-based (practices) indicator instead of a results-related one.

Lastly, as shown in the literature but also by real-life examples, transparency is liable to promote the emergence of an undesirable social norm [1], even leading to widespread non-compliance with entitlements.

A certain number of conditions and improvements have accordingly been proposed to enhance the acceptability of transparency: data access should be restricted to the OUGC and the user itself [4], the nature of data available to all being less personal (on a collective level? anonymous?); a mediator should be placed in charge of resolving cases of exceedance as opposed to internal policing [1]; communication of information accessible to the public must be properly handled to avoid demonising [1].

In conclusion, transparency would seem to be all the more effective as the basins where it is applied are limited in size [1], and all the more acceptable insofar as it is justified by a generalization of the principle over all users (including drinking water, industry...), as well as over all types of information (water needs, sectorial constraints...) [2].

5.2 Negotiation

Visibly transparency and negotiation cannot be dissociated: transparency thus comes across as an essential basis for negotiation over volumes [3], for it rules out suspicion.

The negotiation tool was perceived as globally positive in principle [3], despite the fact that quite a large number of limitations were identified as to its implementation.

Its main advantage is that it allows an improved allocation of the resource to be achieved [6]: through the mutualisation of needs and the adjustments it allows between groundwater users in line with crop rotations and other constraints. The allocation can be adjusted within an annual context (climate, agronomy...). Likewise, an agreement over water volumes prior to the irrigation season offers a better guarantee to groundwater users of being able to rely on their volumes, avoiding emergency management and having restrictions imposed [1].

Negotiation also promotes dialogue, accountability and conflict resolution [3]. Some comment on this: “We talk about it, have a row about it, fight over it [...] but we do manage to communicate”. Negotiation is a good way to maintain dialogue, whether in the farming sector or between irrigators and the administration. Finally, some speak of successes of negotiation in certain

areas not far removed from those addressed [2]. In the Isère Department, adjacent to the eastern Lyon region, the Chamber of Agriculture has been organizing negotiation meetings for a number of years. This process has been thoroughly appropriated by the users, who now work things out spontaneously. Such transfers are also commonplace in the ASA[4], although they are marginal in terms of the volumes exchanged.

However, certain limitations have been identified. First of all, the individualistic nature of the farmers might prevent them from coming to terms over volumes [7]. Furthermore, farmers stress how little latitude they have in reducing their withdrawals [7]: the available volume is extremely restrictive; climate and needs uncertainties are too large for them to be able to run the risk of relinquishing a volume of water [2]; irrigators have investments on which they must obtain a return and which require an optimization of the irrigation potential; lastly, certain holdings have incompressible needs (such as arboriculture). In the end, most consider that the exchanges would take place on the fringes, but to little avail, if not the contrary: the creation of tensions, notably between crops that can be adapted (cereals) and those with invariable needs (arboriculture) [2]. Lastly, the capacity of pumps would in itself place a limit on volume exchanges [1].

A negotiation process that is both equitable et efficient can only be guaranteed if: organisational rules and a framework for discussion are clear-cut and accepted by all [3]; exchanges are balanced [1] ; individual quotas are ensured over the long term [2]; and exchanges are non-monetized [3].

Some consider the negotiation solution only in specific contexts:, the presence of cereal growers, better able to adapt, is necessary [2]; the smaller the group and the better the members know each other outside the context, the easier negotiation will be [2]. Other points have been brought up: opening up possibilities for exchanges throughout the season [1] ; turning the water over to the OUGC, placed in charge of redistributing it[1]. Many agree over the need for a change in attitudes [1]. Lastly, negotiation stands no chance of being useful and effective without transparency established at the outset [1].

5.3 The Payment-Penalty System

A majority of participants reject the payment-penalty system (P&P). First, they are opposed to the principle itself [15], bringing to mind the “carrot and stick” philosophy. Purely economic regulation encourages irresponsibility and

[4] Association Syndicale Autorisée (Authorized Syndical Association): An ASA of irrigation is a water user association whose members share infrastructure for distributing water.

moves farther away from the objective of a balanced management of the resource [6]. For many, the system is “perverse” [3]: reduction in agricultural production [3] ; financial transfers between irrigators [1]; modification in incentives to produce and consequently a change in the choice of crops (only those crops with the highest added value will continue to be irrigated), inducing imbalance in downstream sectors [2]. Some accordingly point to a risk of plant relocations [4] and, more broadly, to endangered regional competitiveness [6]. Assigning a value to water thus seems hazardous [1], and many people evoke the risk of conflicts and distortions linked to the system’s financial aspect (such as the development of a black market or of pressure brought to bear on the OUGC...) [7].

Such a system would give rise to many injustices [15] : it would generate deadweight effects [3], unwarranted rents and opportunistic behavior on the part of irrigators who effortlessly cut back on their consumption (owing to favorable climates or soils [2], an unlimited substitution resource...); many groundwater users would have no choice between payment and penalty [5], being forced to pay the latter: young farmers bearing a heavy debt load [1], long-term crops with uncompressible needs [5], sandy or shallow soils [1],...

From a practical standpoint, the system appears too complex to gain a thorough understanding [4] of, whether for the manager [1] or the irrigator [3]: the calculations, overly subject to uncertainties, interfere with the legibility and incentive value of this tool.

Lastly, the incentives would not be robust enough to weigh on practices [1] and would be ineffective in ensuring the abstractable volume would be respected [3], since exceedances would outweigh the water saved, particularly during dry years [3]. Indeed, the latitude available for reducing withdrawals is slim [8]: the volume allocated is already very small [3], efforts at reduction have already been implemented [2], investments have not yet yielded their benefits and certain water needs cannot be further restricted (arboriculture, vegetable crops under contract with imposed quality standards) [1]. Moreover, the payment is not a certainty [6] and is not the determining factor in the choice of crop rotation [5], as is the price of cereal grains [5]. Finally, the size of the penalty is not sufficiently deterrent to reduce withdrawals for high added value crops (arboriculture, corn, seed corn...) [4] or during droughts [2].

The incentive aspect of the tool is nevertheless a subject for debate: some participants are convinced [9] that it induces farmers to adapt their crops and revise their conception of irrigation (“it only works when you dig into your wallet”) [4]: indeed some farmers consider the amounts to be dissuasive and coherent with the fee structure in effect in ASAs. The fact that the penalty is proportional to the level of exceedance enhances the incentive value compared to a fine-based system, currently in place [1]; this system also

satisfies the need for a repressive framework to deal with excessive use [4], but also the need to reward efforts which at present receive little or no recompense [2]. This principle is all the more valued by farmers because it allows them to remain in an individual, non-collective strategy [1]. Another signal advantage: the penalty is an element of flexibility, albeit costly, compared to a rigid individual volume [3]. Lastly, the closed financial framework managed by the OUGC is perceived particularly favorably [3], provided the OUGC properly controls its implementation [4], specifying sums that are clear, acceptable and guaranteed [3].

Ultimately, the Payment-Penalty system tends to have been viewed negatively, but it has allowed interesting alternative propositions to be brought to light. To make it more incentive or equitable, the level of the penalty should be indexed on the climate of the year [1], on cereal prices [1] or on the flow-rate of rivers [1]. Many would envisage the penalty in terms of volume rather than financially [4]. The payment is likewise subject to debate: some consider it not legitimate, with only the penalty that should remain [3]; others propose to set its level ex ante in order to render it more incentive [3]; some suggest that it should be defined in terms of volume (usable the following year) [1]; finally, others propose to replace it by investing the amount of the penalty in measures that incite water savings or in the creation of resources [5]. One participant even suggests creating an insurance fund that could be mobilized during dry years to compensate farmers who refrained from irrigating, in order to ensure the balance of the resource [1].

5.4 The Contract of Solidarity

The contract of solidarity has given rise to contrasted reactions between different types of terrain and different players (institutional or irrigators).

The principle is viewed favourably by a majority of institutional players and many farmers in basins already facing water scarcity [10]: it would be the “ideal solution”, “theoretically” [2] at least. One group even proposes to set it up as soon as may be [1], with others also considering it could be implemented rapidly [2]. It starts out, indeed, with a collective approach familiar to the agricultural sector [12]: farmers are already practicing it when they pool equipment or labor [1], through establishing protected seeding areas [1] or pooling water distribution [7].

It is based on the self-management principle [9], thus on accountability [5], which offers the advantage of escaping oversight by the administration [3].

It is a tool that wagers on human relations [5], founded on the principles of solidarity [2], dialogue [1], sharing [2] and confidence [1]. However, human relations lie at the heart of the problem today: individualistic reasoning

prevails and farmers have a hard time coming to terms with each other [8]. This human dimension is also a source of risk: it would be hard to have commitments be respected within a group simply by virtue of self-discipline or self-policing [5]; risks of conflict are high between farmers [11] notably if a collective penalty is imposed [3], but also in the event of a drought [2] or if the adherents have the impression that efforts are asymmetrically divided out [5].

One of the main factors of inefficiency cited by the participants: the risk of a low rate of contractualization [13]. The dominance of individualistic reasoning [12] would make it impossible to generalize the contract, which would only be able to emerge "among friends" [4], and therefore marginally. Moreover, there is no advantage for virtuous farmers to enter into a contract [1], and they will be unwilling to take the risk of having to pay a collective penalty [4]; certain crops always require water [4] and others have variable needs that are hard to anticipate [1], which will motivate farmers to retain water for safety's sake [2]; irrigation equipment must be used profitably [2]. On a more technical level, other limitations are identified: too little intra-zone diversity [3], sectors that are too small [1], insufficient individual pumping capacity of ensuring water allocation exchanges [2].

Some are convinced that instead of simplifying management, it makes it more complicated by inserting an additional echelon [5]. Others have misgivings over the contract's collectivist principle [3] or else fear a monetization of exchanges [1]. A feeling of injustice may also develop among isolated individuals who, for technical reasons, are unable to adhere to a contract [1], but more particularly with members of the group who could be penalized without being at fault [3]. Other risks are brought up: contract signers will be faced with a dilemma of collective action within the group and will tend to reduce their individual efforts in terms of water savings [1]. Finally, some individuals fear negative repercussions on the economy, such as the relocation of client firms [1].

Many mention difficulties in applying the contract [11]: the risk of ineffective internal control [5], strong uncertainties (climate-related, environmental or economic) that would impact its success [1], the difficulty, or even impossibility, of reaching an agreement on certain sensitive hydrogeological sectors [2].

The economic advantage of adhering to such a contract was debated. Economic obstacles might render this tool valueless [6]: the management of a farm is individual by nature [1] (individual investments, contracts with firms that are incompatible with collective water management); this tool appears too restrictive in the eyes of some [1] (additional rules, its administrative and human management too heavy), overly rigid (in the event of drought or other

unforeseen events) [1] and not incentive enough (small expected gain) [4]. But others do point out a few advantages [12]: for managers, it is a cost-reducing solution [1]; for farmers, an opportunity to maximize revenue [3], by playing on complementarities between farms [5], or even pooling crop rotation [1]. It affords flexibility [2], and opens up the opportunity for avoiding crises and reducing individual constraints [5].

Thus, among the conditions that guarantee the success of the contract, many are economic in nature [12]. It first appears essential to have, within the same basin, a variety of crops [8], with water requirements which are heterogeneous and variable over time, so as to ensure reciprocal complementarity. Some go so far as to mention the need for pooling crop rotation [6], investments [1], and even revenues [1]. It would also seem that setting up a contract would be all the easier if crop rotations include a minimum of annual crops, like cereals, which readily adapt to variable resources [5]. Inducement to contractualize must assume a positive, not a negative, aspect [1]: creating additional water reserves in parallel, not doubling the penalty in the event of non-compliance [2], continuing to propose individual as opposed to collective penalties [2]; some even propose to increase the level of penalty for irrigators who remain outside the system so as to motivate them to opt into the contracts.

To guarantee its success, the contract must be properly designed [12]: with clearly defined rules of play [4] and terms of governance [6], the intervention of a mediator to resolve tensions, the physical capacity for exchange (with suitable pumping capacities) [2] and being aware of the situation in real time (via information transparency, presupposing a centralized computer support facility for the information) [3].

Lastly, the contract can only be effective under certain conditions of scale and adhesion. Some believe that the contract must cover all the irrigators in a given basin [5] and accordingly should be mandatory; for others, this would be counter-productive and non-incentive, such that it is of prime importance that voluntary adhesion remain a basis for the contract [3]. However, all are agreed that each contract must be restricted to a single, coherent hydrogeological zone [2]. As to the number of signers, a compromise apparently needs to be found between a fairly restricted group within which negotiation and social control could be brought to bear and one with a broad enough scope to have a true positive impact on the resource [10].

To conclude, the contract of solidarity is perceived relatively positively in principle and could be effective provided incentives are strong enough for irrigation to start to be viewed in a new light. It is cited by many participants as a solution “for the future”, capable of providing answers to mounting economic and environmental constraints.

6 Conclusion

In a context of policy reform, our work aimed at exploring and evaluating various scenarios of decentralized groundwater management. Farmers will likely tend to exceed their quota to cope with climate variability and other sources of environmental and economic uncertainties. Therefore, GWUAs will need instruments to tackle this enforcement problem. We considered GWUAs as micro-institutions in the sense of Ménard (2003). In our conceptual framework, such an institution ensures processes than can be organized in various ways so that a scenario of management consists of a unique combination of these processes. We focused on the enforcement process. We explored four levers of enforcement (economic incentives, negotiation, transparency and joint liability) and designed three scenarios. Although fitting into CPR decentralized management literature, the main innovation of this paper was to adopt a participatory foresight approach aimed at evaluating tools for the 2020-2030 timeframe. We carried out 16 workshops in 5 areas in France, and gathered 124 participants, both institutional representatives and farmers. The first scenario, that couples negotiation and transparency, gave rise to contrasted reactions. Negotiation has been seen as a positive tool, as it improves water allocation, enhances dialogue and can solve conflicts, even if individualism is its main obstacle. On the contrary, transparency slightly shocked: although increasing social control and allowing for informed discussions, it seems hardly legitimate or socially acceptable. The penalty-payment scenario raised quite negative reactions: the instrument appears ineffective, uncertain and unnecessarily restrictive. Even if the joint liability contract has been approved in principle, as it relies on dialogue, solidarity and trust, farmers are reluctant to give up decision autonomy and become dependent on others' strategic choices.

Generally speaking, farmers wanted to draw our attention on their incapability, for technical, financial and agronomic reasons, to save significant amounts of water in the future. But farmers did not only react to our scenarios, as they more widely question the quota system currently being set up, based on the assumption that groundwater is overexploited, that they also contest.

In this work, we focused on two processes out of the six a micro-institution ensures. Others processes and new combinations can be addressed. Particularly, participants emphasized on the necessity that they be associated to the decision making process, so that it appears to be a condition for an easier rules enforcement. Thus, various decision making processes have to be imagined and tested.

Finally, the diversity of case studies give rise to an abundance of arguments that have now to be analyzed closely in order to identify context factors (hydrogeological, agronomic, economic and social factors) that may have influenced opinions. This is an essential analysis for helping the design of appropriate micro-institutions that have to be suited to each specific situation.

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