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Transitioning out of Open Access: a closer look at Institutions for Management of Groundwater Rights in France, California, and Spain

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Key Points:

- The paper presents institutional mechanisms influencing allocation decisions in agriculture in France, Spain, and California.
- An evolution is observed towards greater oversight over operational rights of accessing and withdrawing groundwater.
- A system of check-and-balances are needed to ensure that all three sustainability pillars (economic, social, environmental) are met.

Keywords: Groundwater governance; Groundwater allocation; Common-pool; Groundwater Overexploitation

Abstract

Many regions around the world are transitioning out of open access to groundwater resources in order to tackle over extraction by irrigated agriculture. However, the state has limited capacities to regulate effectively agricultural groundwater use. This paper evaluates how users and public authorities can co-manage groundwater extraction by agriculture. Based on Schlager and Ostrom's "bundle of rights" framework, the paper examines how decisions over access and use of groundwater resources are made in France, Spain and California. The three cases share a common strive to involve groundwater users in decisions over how to reduce over extraction of groundwater resources. However, different choices were made regarding the institutional set-up for user involvement in allocation decisions. The paper presents the diversity of institutional arrangements influencing groundwater allocations in the three cases, and the relative involvement and power of users and public authorities over these institutions. The papers shows the different ways in which "comanagement" may be made operational for managing agricultural groundwater use.

1 Introduction

Groundwater forms the invisible, subsurface part of the hydrological cycle, playing a vital role for maintaining base flows of rivers during the dry seasons. It is also a vital source of water for modern economies, accounting for 25% of total water extraction worldwide and a quarter of the irrigation water used to grow the world's food (Aquastat, 2016). Yet, aquifers are being over-exploited at an alarming rate in many regions around the world – a situation that is expected to worsen under climate change as recharge rates will be increasingly affected (Famiglietti, 2014; Taylor et al., 2013). Groundwater depletion contributes to the decisions by water managers to 'close' access to water resources in aquifers and river basins (Molle et al., 2010). As societal and environmental needs cannot be met for at least part of the year, water managers must deal with complex trade-offs between economic interests, livelihoods, and environmental priorities.

To tackle overexploitation, groundwater management is progressively shifting from an open-access regime of water resource extraction to one of regulated access all over the world (Giordano et al., 2009; Shah, 2009). Regulated access typically relies on setting a sustainable flow rate or volumetric cap on total water extraction, and reducing and maintaining extractions at or below that cap (Rinaudo et al., 2020). It can also rely on a pigouvian tax or restrictions imposed when sustainability limits are reached (for exemple groundwater threshold levels). The core issue when closing access to water resources becomes how to best allocate limited water supplies between competing users, and between users and the environment. It involves setting up processes and mechanisms which enable social actors to share water according to a recognised set of values and priorities.

Much academic debate has focused on the question of who should control or supervise allocation decision-making, with no conclusive outcome as to whether state or community approaches are preferable (Bruns et al., 2005; Rinaudo et al., 2019). On the one hand, state approaches appear more accountable, but they have usually failed to effectively reduce groundwater use to sustainable levels (Molle and Closas, 2020b). On the other hand, community approaches appear more legitimate, at least to the regulated. They have been most effective where the community had a social basis for collective action, for example a common irrigation infrastructure, or where they face urgent and irreversible threat to their livelihoods (Schlager, 2007; Molle and Closas, 2020a).

A more nuanced approach has been called for, in the form of comanagement, whereby responsibilities are shared between the state (through e.g. government agencies) and users (through e.g. organisations) (Molle and Closas, 2020a). Comanagement sets out to establish institutional arrangements with shared decision-making powers between the state and users, in order to overcome the weakness of state and user based approaches taken individually and maximize synergies (Molle and Closas, 2020a).

Comanagement has been observed in a variety of contexts, some studies highlighting the varying levels of shared decision-making that comanagement exhibits in different governance contexts, and factors conducive to a degree of success (Molle and Closas, 2020a). However, the specific institutional arrangements supporting comanagement in decision-making over groundwater allocations have not yet been examined in detail. How do actors with different social, policy, legal and cultural conditions and different histories set out such institutional arrangements? How do they share power over allocation decisions? What system of rules and instruments can guarantee effective, efficient and fair decisions and outcomes (Schlager, 2007)? This paper aims to examine this diversity in institutional design, in particular by presenting the variety of ways that authority between governments and users can be shared within institutional arrangements.

To illustrate this diversity, three cases, France, California and Spain, were selected as they share a common strive to move from open access towards regulated extraction in agriculture using comanagement arrangements. In particular, all three cases impose the creation of user organisations to better regulate groundwater extractions. At the same time, legislators of the three countries made fundamentally different choices regarding institutional arrangements for comanagement and the relative role of the state and users' organisations.

The remainder of this paper is organised as follows. The next sections present the theoretical framework used to examine the France, California, and Spain cases, followed by a brief background on each case to outline the rationale for choosing these cases, before delving into the details of their institutional arrangements influencing groundwater allocation.

2 Groundwater allocations of groundwater rights in agriculture

2.1 Approaches to groundwater allocation in agriculture

Four general approaches to allocating water resources in agriculture can be contrasted. First, allocations can be made (and if necessary adjusted over time) through administrative procedures, such as a permitting regime, managed by public authorities. Second, allocations can be made through court adjudication where a judge mediates the allocation process. Third, water can be allocated by agricultural users themselves based on collectively agreed rules, for instance by a group of farmers in collective irrigation systems. Fourth, allocations can be based on market mechanisms, for example when water use rights are made tradable or when charges and tariffs are applied to influence water use (Dinar et al., 1997). It is important to note that, in any groundwater resource setting, different allocation mechanisms may co-exist, for example, when a State based permitting system and a trading scheme are used in combination to manage groundwater resources.

Each approach is embedded in contrasting ideas of what counts as legitimate and accountable decisions. Allocations made by administrations are deemed legitimate when State decisions aim at balancing interests between different social groups (distributive justice). In contrast, the legitimacy of decisions made through adjudication derives from their accountability through a transparent and legalistic approach supervised by the judiciary. The

involvement of users may be justified for procedural reasons (social justice), while market mechanisms are deemed justified when they contribute to maximise economic efficiency.

Each allocation approach (administrative, legalistic, user-based, market) accentuates the role of different social actors in allocation decisions. User-based and market-based allocation systems put more authority on appropriators of the groundwater resource, while administrative and legalistic ones defer authority to non-appropriators and higher jurisdictions (e.g. the State, the judiciary). However, an allocation system may be designed to increase the role of specific social actors, for example when public authorities establish participative processes to inform or influence allocation decisions.

2.2 Examining agricultural groundwater allocations through the “bundle of rights” framework

The four approaches described above provide a general picture of how allocation decisions can be made, but they do not describe well how authority can be shared in the process of allocating groundwater. To examine more closely how authorities and users share authority over groundwater allocations, it is useful to take a closer look at the different elements that constitute the right to use groundwater for agricultural purposes. To do so, it we look more closely at the definition of “groundwater rights”, and more specifically the concept of property rights attached to groundwater.

In this paper, we adopt the conceptual framework developed by Schlager and Ostrom (1992) which is particularly relevant in the case of common property goods. It diverges from the commonly held view by economists that a property right is about having an ‘*exclusive and unalienable right over something*’. Instead, it borrows from the legal tradition of property law, the view that property is not merely ownership of things (i.e.g the relationships between owners and “things”) but it is a set of legal relationships among people (Johnson, 2007). In other words, a right to use a natural resource is not an absolute and unlimited right, but it stems from a particular web of social relations that legitimise access and withdrawal of that natural resource. It is the ‘*power to take particular actions*’, and that power is limited by institutions, i.e. rules set by social actors such as state administrations or groups of resource appropriators.

Property rights are thus conceptualised as a ‘bundle of rights’, independent of each other, but that can be held cumulatively. For each right that a social actor holds, formal and informal rules exist that authorize or require actions relating to the exercise of this right. Only the holder of the complete set of rights possesses the authority akin to those imagined in classical economics.

Schlager and Ostrom’s “bundle of rights” framework differentiates between five components of a property right over a natural resource (Table 1). If we apply that framework to groundwater, access rights refer to the authority to create or operate a well, or connect to an existing infrastructure distributing groundwater. Withdrawal rights relate to the authority to extract groundwater. Management rights refer to the authority to design rules that determine how water can be extracted and how compliance with those rules will be ensured. Exclusion rights refer to the authority to determine who can access (or not) groundwater resources. And finally, alienation rights refer to the authority to sell, lease and transfer all previous rights. The rights of access and withdrawal are also called operational rights by Schlager and Ostrom (1992), while the three other rights are referred to as collective choice rights.

Table 1. The bundle of rights over groundwater use in agriculture (modified from Mongruel et al., 2019)

Type of rights	Definition applied to groundwater allocations
<i>Operational rights</i>	
Access right	The authority to create a well / borehole or to connect to an existing infrastructure extracting and distributing groundwater
Withdrawal right	The authority to extract groundwater
<i>Collective choice rights</i>	
Management right	The authority to design rules specifying how groundwater can be extracted as well as rules ensuring compliance from users
Exclusion right	The authority to decide who can access groundwater
Alienation right	The authority to sell, lease or transfer groundwater operational and management rights

2.3. Sharing “rights” over groundwater allocations

In the ‘bundle of rights’ perspective, property rights are viewed as relative and shared between actors (Orsi, 2013). Social actors intervening in the definition and exercise of groundwater rights for agriculture are numerous: state or local regulatory agencies, landowners, tenants or individual water users (e.g. businesses, corporations), communities or groups of individuals (i.e. user organisations). We can illustrate the variety of ways these actors share power by looking specifically at the sharing of operational and collective choice groundwater rights (Figure 1).

The rights to access and withdraw can be held individually by landowners or farmers drilling a borehole and extracting groundwater for their own purposes. Alternatively, groups of groundwater users may collectively hold a common access and extraction right. Those rights can also be held and managed administratively by the State.

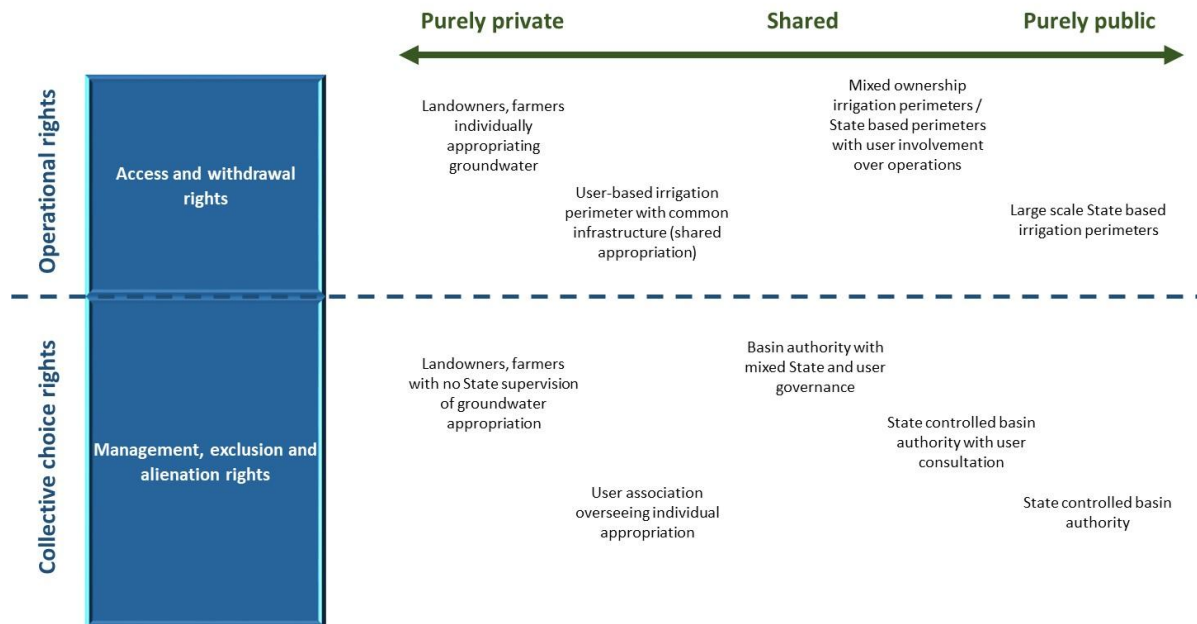
In a pure state-controlled system, the five rights will be held by a state agency, such as a basin authority with no user involvement. In contrast, in a pure privately controlled system, the five rights would be held by landowners or farmers, with no oversight by public authorities or communities over where, when, by whom and how groundwater is appropriated by, and exchanged between, users. In a pure community controlled system, the rights would be held by a community organisation such as a water user organisation, with no individual appropriation of any of the five rights.

In a comanagement setting, components of the bundle of rights can be shared in different ways between users and the state. For instance, the State may control management rights, placing spatial and temporal restrictions on the amount of groundwater that can be extracted to ensure long term sustainability, while users (organized in organisations) may still hold the right over who can access and extract groundwater (i.e. alienation and exclusion rights).

In other cases, alienation right might be also held by the State or by water user organisations. This would imply that individual users would not be allowed to bequeath, sell or temporary lease their withdrawal rights to a prospective user without authorisation by the State or the water user organisation. The State or water user organisation may even hold the exclusive power.

The following section presents a short overview of groundwater management in France, Spain, and California, before examining in more detail how authority over the five “rights” is shared in each case.

Figure 1. Sharing groundwater rights: an illustration of possible governance arrangements



3 Groundwater management in France, Spain and California: context

A wide diversity of institutional design options exist around the world for ensuring sustainable groundwater extraction and allocating groundwater (OECD, 2017). However, only a few clearly set out to tackle over-extraction of groundwater resources while simultaneously encouraging comanagement between the State and users (Molle and Closas, 2020a). This paper focuses on three cases, i.e. France, Spain and California, which, in recent years, have moved towards more holistic and participatory sustainable groundwater management planning.

In both France and Spain, the EU Water Framework Directive (WFD) adopted in 2000, complemented by the Groundwater Directive (2006) imposes to achieve good quantitative and chemical status of groundwater bodies. Reaching good quantitative groundwater status means avoiding depletion, intrusion of low water quality from surface, coastal or other groundwater body as well as maintaining groundwater-surface water flows to avoid any significant diminution in the ecological status of surface waters and groundwater-dependent ecosystems (Klove et al., 2011). Public authorities were tasked to prepare River Basin Management Plans (RBMPs) to achieve WFD environmental objectives by 2015, and at the latest by 2027.

In California, the 2014 Sustainable Groundwater Management Act (SGMA) has the objective to achieve groundwater sustainability in prioritized groundwater basins by avoiding “undesirable results”, i.e. groundwater overdraft, groundwater storage reduction, saltwater intrusions, depletions of interconnected surface waters that impact beneficial uses of surface waters, land subsidence and water quality degradations. Of the state’s 517 groundwater basins, 109 basins have been prioritised. Within these areas, the State required the formation of local Groundwater Sustainability Agencies (GSAs), entrusted with the responsibility of preparing and implementing Groundwater Sustainability Plans (GSPs) to achieve groundwater sustainability (e.g. the avoidance of undesirable results) within a 20-year window. In contrast

to the WFD, SGMA does not require restoring groundwater basins; it only aims to avoid further deterioration based on conditions as they existed in January 2015.

These ambitious policy targets must account for complex legal traditions regarding groundwater appropriation. Until the late 20th century, groundwater in France, Spain and California was mostly left to landowners' appropriation. With its 1985 Water Law, Spain was first to change this situation by including all groundwater in the public domain. France did not make its groundwater public; instead, the 1992 French Water Act affirmed that water was the "common heritage of the Nation", seemingly placing water into the category of 'common' good. Groundwater in California is entrusted to the State for the people of the State. Users may establish the right to use water – subject to California constitutional limitation of reasonable use and avoidance of waste.

Table 2 presents some key physical, socio-economic and institutional background information on the three countries. Considering these recent policy and legal developments, the next section examines in more detail how public authorities and groundwater users exercise authority over the 'bundle of rights'.

Table 2. Key physical, socio-economic and institutional characteristics of selected cases

	France	Spain	California
Environmental			
Average annual rainfall (mm)	900	636	530
Total agricultural area (million ha)	29	17	17
Total irrigated land (million ha)	2	3,35	4
Water extraction for irrigation (km ³)	3	17	35
Groundwater extraction for irrigation (Mm ³)	1	5	10
Socio-economic			
Number of farm businesses	515 000	1 million	80 000
Institutional			
Key groundwater legislation on quantitative management	1964 Water Act; 1992 Water Act; 2003 amendment (transposition of the EU WFD) 2006 Water Act	1985 Water Act; 2003 amendment (transposition of the EU WFD) 2001 Water Act	1992 GMA (AB 3030); 2002 modifications to GMA (SB 1938); 2014 SGMA; 2016 AB 1390 and SB 226
Permitting regimes on groundwater extraction	Yes (national)	Yes (river basin level)	No

4 Examining the bundles of groundwater rights in France, Spain and California

4.1 France

In France, groundwater access rights are regulated under both the mining and the environment codes. A permit is requested for drilling the well (mining code), which is in general automatically granted, after a "declaration" to the State, except if the proposed well is

located in a drilling restriction area (for instance an area protected for water supply). The environment code also requires a pumping permit for the installation of the pumping device itself (Rinaudo, 2020). The pumping permit, which defines a maximum pumping flow rate, is only necessary if the capacity of the pump exceeds 8 m³/h. The permit is obtained after a “declaration” to the State, if the maximum anticipated annual extraction (based on the capacity to pump) is below 200 000 m³. A more complex authorisation process that assesses the potential impact of the withdrawal on third parties and on the environment is required if the pumping capacity is above 200,000 m³. Therefore, it is important to note that the “declaration” process does not automatically authorise the well. The State can oppose the drilling request or the installation of a pumping device on an existing well within two months of the declaration. No new pumping permit will be issued if the basin is declared fully allocated by the State. No time limit exists on these permits, but they can be cancelled without compensation when justified for reasons of overriding public interest.

Withdrawal rights are regulated under a series of water laws developed over the last 50 years that gradually strengthened requirements for obtaining a permit to extract water (Rinaudo, 2020). Metering of extractions is compulsory under the 1992 Water Law. An annual extraction permit is required if annual extraction exceeds 10 000m³. Lower extraction thresholds (i.e. 1 000 m³) are implemented in specific protection zones, such as catchments and aquifers which are classified as having a structural water deficit (i.e. called “restricted” areas or i.e. “Zone de Restriction des Eaux”), in alluvial aquifers closely linked with surface water, in ecologically sensitive areas, and in areas protected for drinking water production. The extraction permits include an annual maximum extraction volume, sometimes broken down seasonally or monthly. These permit has a one year validity and are almost systematically renewed.

In overexploited basins (i.e. “restricted” areas), withdrawal rights are further constrained to ensure the reaching of sustainable extraction caps. Under the 2006 Water Act, Sustainable Extraction Limits (SELs) must be defined in volume and withdrawal permits granted to users must be adjusted to meet that limit. SELs are defined to ensure the achievement of the environmental objectives of the WFD (see section 3). In overexploited basins, farmers no longer obtain an individual extraction permit and instead receive a notification from an agricultural water user collective organisation called OUGC. The OUGC holds a 15-year bulk extraction permit on behalf of all farmers extracting in the same hydrological unit (Rouillard and Rinaudo, 2020).

Collective choice rights over management and exclusion are held collectively in a nested framework. At the catchment level, Local Water Commissions (LWCs) composed of representatives of the State, local governments and all users participate to the development of catchment management plans which set SEL and specify how this limit is apportioned between agriculture, urban water supply and industry (Rinaudo, Marchet et al., 2020).

In unrestricted basins where water resources have not yet been fully allocated, the State retains management and exclusion rights. Individual permits are issued to each claimant. In overexploited basins classified as “restricted areas”, management and exclusion rights over the allocations to agriculture are transferred to the OUGC. The OUGC has authority over how the bulk volume will be shared on an annual basis between individual farmers and is in charge of developing rules to reduce current extraction and align it with sustainable extraction limit set at the basin level by the Local Water Commission. Hence, through the OUGC, farmers collectively agree on how the volume dedicated to agriculture should be shared among themselves. They also can define criteria authorising new wells and can recommend the closure or substitution of specific wells. The State retains a close oversight by validating the rules developed by the OUGC and the annual allocation plan.

State control over allocations is further reinforced through another regulatory instrument created by the 1992 Water Act which offers the possibility to impose temporary restrictions during drought. Restrictions apply on groundwater extraction in order to ensure minimum aquifer levels and river flows, defined as the levels that ensure sufficient water is available for environmental flows and “priority” uses (e.g., drinking water, national defence infrastructure, fire services). However, restrictions are not the sole decision of the State, but follows a pre-design emergency plan co-developed and co-implemented with water users in drought committee groups. Hence, management rights over drought restrictions are shared between very different types of users.

Acces and extraction permits associated with the well are legally not transferable with market mechanisms in France (Herivaux et al., 2020). They are generally transferred with the land, by decision of the local administration. Thus, the value of the groundwater access and extraction rights is included in the price set for land transaction, meaning that there is an implicit market for groundwater. However, in restricted areas, the users’ organisation (OUGC) needs to approve (and can oppose to) the decision to transfer water extraction rights with land. In that case, no compensation to the former beneficiary is required.

In restricted areas, the OUGC, as the holder of the bulk extraction permit, is free to develop its own rules to reallocate water on an annual basis, for instance based on meteorological and hydrological conditions, or on yearly requests by farmers within their management area. OUGC have developed a wide variety of allocation rules (Rouillard and Rinaudo, 2020). No specific legal obligations exist, except that OUGC decisions must be transparent and reflect a fair and equal treatment of all users in its reallocation decisions.

Table 3 presents a summary of the procedures and requirements adopted in France around the five groundwater “rights”.

Table 3. Characteristics of groundwater rights in France

Type of right	Nature of right	Owner of right	Description
Access right	<ul style="list-style-type: none"> An authorization to drill a well A pumping authorization, specifying a maximum pumping flow rate. Valid in perpetuity Can be revoked by administrative decision, leading to well closure (without compensation) 	<ul style="list-style-type: none"> Landowners 	<p>General situation: The user submits an individual application (no publicity requirement). The State agency must verify the absence of impact of the proposed pumping on third parties (incl. environment). The impact assessment procedure is simplified if annual abstraction is less than 200.000 m³. Pumping of less than 10.000m³/year are exempted. Existing users are not given the opportunity to oppose to the delivery of a new authorization.</p> <p>In restricted basins: Exemptions only applied to pumping of less than 1.000m³/year. No new authorization granted if fully allocated (withdrawal right)</p>
Withdrawal right	<ul style="list-style-type: none"> An individual annual withdrawal authorization, specifying a maximum volume that can be pumped during a season (sometimes per month) Validity : 1 year, renewable 	<ul style="list-style-type: none"> Landowners OUGC in priority basins 	<p>General situation: The State agency grants the volume requested after verifying the absence of impact on third parties / environment (the environmental impact assessment usually has to be performed when granting an access right).</p> <p>In restricted basins: Farmers apply each year for authorisation to pump water to OUGC. The OUGC compiles requests and adjusts individual ones as necessary to meet SEL. The OUGC sends the allocation plan to the State agency, which notifies extraction authorization to each farmer.</p>
Management right	<ul style="list-style-type: none"> Right to define SEL at catchment and aquifer level Right to apportion SEL among economic sectors 	<ul style="list-style-type: none"> Local Water Commission, composed of representatives of all users, local government and state agencies 	<p>General situation: no definition of SEL by the local water commission</p> <p>In restricted basins: The Local Water Commission defines the SEL. It allocates the SEL between the drinking water sector, industrial use and agriculture. SELs can be defined at the level of sub-catchment and other coherent hydrological units.</p>
	<ul style="list-style-type: none"> Right to set limits on extractions by individual agricultural user Up to 15 years 	<ul style="list-style-type: none"> In non-restricted basins: the State In restricted basins: OUGC 	<p>General situation: only the State Agency can reduce individual authorisations of farmers.</p> <p>In restricted basins: Farmers form an OUGC which is in charge of designing a water sharing plan. This plan, which specifies a spatial distribution of individual extraction limits is submitted to the State Agency specifying a spatial distribution of individual extraction limits, accompanied with an environmental impact assessment. The State Agency grants a bulk withdrawal authorization to this OUGC for up to 15 years. OUGC annually adapts the allocation within limits specified in the bulk authorization and submits it to the State Agency for approval.</p>

	<ul style="list-style-type: none"> • Right to temporarily restrict extractions during a drought 	<ul style="list-style-type: none"> • State, with consultation of representatives of users in the basin in drought committee groups 	<p>Minimum river and aquifer flows are defined as the levels that ensure sufficient water is available for environmental flows and “priority” uses (e.g., drinking water, national defence infrastructure, fire services). Pre-defined restrictions are phased in as water levels reach pre-defined thresholds</p>
Exclusion right	<ul style="list-style-type: none"> • Right to declare basin closure (i.e. definition of restricted area) 	<ul style="list-style-type: none"> • State 	<p>The State declares basin closure on the basis of hydrological studies showing the long term imbalance between renewable resource and extraction, taking into account environmental flows. The declaration is made in coherence with the relevant River Basin Management Plans and the objectives of the WFD.</p>
	<ul style="list-style-type: none"> • Right to include a new agricultural user 	<ul style="list-style-type: none"> • In unrestricted basins: the State • In restricted basins: OUGC 	<p>General situation: the State accepts new users until the basin is fully allocated. It works on a first, come, first served basis</p> <p>In restricted basins: the OUGC sets out rules to accept new users. In some OUGC, no new users are accepted if the basin is fully allocated. In others, individual extraction limits are reduced to allow the introduction of new users.</p>
Alienation right	<ul style="list-style-type: none"> • Right to transfer well and pumping authorisation • Right to transfer withdrawal right 	<ul style="list-style-type: none"> • In unrestricted basins: landowners, with approval by the State • In restricted basins: Landowners, with approval of OUGC 	<p>General situation: well, pumping and extraction authorisations are usually transferred automatically through land sells. However, the State can oppose and cancel the transfer of the authorisation. No temporary (annual) transfer occur between individual user. No permanent or temporary trading is possible.</p> <p>In restricted basins: the OUGC must also approve the permanent transfer through land sells of well, pumping and extraction authorisations. Each year, the OUGC can reallocate volumes from extraction authorisations between individual beneficiaries.</p>

4.2 Spain

Rights to access groundwater in Spain have changed little since the 1879 Water Law, which granted groundwater access rights to landowners. From 1934, access rights are limited by a permitting regime requiring farmers to obtain a permit to drill or dig wells from River Basin Authorities (RBAs), known as Confederaciones Hidrológicas.

Regarding withdrawal rights, since the 1985 Water Act, new users pumping above 7000 m³/year requires concessions for privative use of a public good. Existing groundwater users prior to the 1985 Water Law had a period to either register their historical right as public (concession) for 50 years (Registry of public waters) or keep it as private in perpetuity (Catalogue of private waters). However, the right, if held private, cannot be modified: a request to deepen the well or increase the volume extracted would transform the private right into a concession under the public regime.

RBAs manage the Catalogue and Registry of Public Waters under the 1985 Water Act. The volume of water associated to the concession or private right during registration was dependent on rules established by each RBAs. For example, in the Júcar river basin located in the central-eastern part of the Iberian Peninsula, water rights older than 1985 obtained 5,800 m³/ha for summer crops and 4000 m³/ha for spring crops. Concessions granted between 1986 and 1997 were then allocated 4,000 m³/ha. Since 1997, no new authorizations are granted.

Management and exclusion rights are controlled by RBAs. The 1985 Water Law also gave the RBAs enforcement authority to control groundwater use and impose sanctions for illegal wells and excessive extractions. However, this authority is limited in reality because of the lack of monitoring and control (López-Gunn 2003; AEVAL, 2010; Closas et al., 2017).

Users organisation can be involved in the exercise of management and exclusion rights. Most user organisations in Spain organisation were established for the collective management of irrigation networks supplied by groundwater. Under the 1985 Water Act (modified in 2001), groundwater user organisations must be created when the aquifer has been declared overexploited or where groundwater bodies are at risk of not meeting WFD objectives, in which their main role is the collective management of the overexploited aquifer. It then becomes mandatory to integrate all users extracting from the same aquifer into a single groundwater user organisation.

The groundwater user organisation supervises the implementation and effective control of the extraction plan prepared with supervision from RBAs. Example cases include the Groundwater User Organisations for the Western and Eastern Mancha and the Campo de Montiel. Some groundwater user organisations have been created without a legal imperative, such as the groundwater user organisation of the Eastern Mancha, as a collective effort to stop the deterioration of the resource and to avoid the administrative declaration as an overexploited aquifer (Lopez-Gunn, 2012; Custodio, 2016).

The groundwater exploitation plan can set out measures to reduce annually individual extraction limits associated with concessions and private rights to meet a sustainable extractable volume where the aquifer is declared overexploited or where water bodies are at risk of not meeting WFD objectives. A program with actions for the recovery of the good status of the water body has to be approved and included within the program of measures of the River Basin Management Plans. The action program will order the extraction regime to achieve a rational exploitation of resources in order to achieve a good status of groundwater bodies, and protect and improve associated ecosystems. This can include prohibition of

drilling new wells (i.e. stricter control of access rights), banning the issuance of any new concessions (i.e. stricter control on extraction rights), or temporary volumetric restrictions applied to all individual wells.

The annual extraction restrictions have been usually set as a common percentage of reduction over the current individual pumping water rights (e.g. users were only allowed to extract 20% of their rights in the exploitation plan for Mancha Oriental for year 2007, during a severe phase of a multiannual drought). Additional temporary restrictions can also apply within any one year in the case of seasonal droughts, as regulated under drought management plans (“Planes Especiales de Sequias”). The drought plans use basin-specific state indexes computed as weighted average of relevant observed variables at selected control points, e.g., precipitation, streamflow, reservoir level, and groundwater level (Estrela and Vargas, 2012; Zaniolo et al., 2018) to trigger water demand and supply measures when entering a drought period (Carmona et al., 2017).

The concessions for irrigation can be legally reviewed and reduced in cases where it is proven that the needs of the concession holder can be fulfilled with a lesser endowment or a more efficient use of the resources, which contributes to conserving groundwater resources. For these purposes, RBAs can carry out audits and controls of the concessions, in order to verify the efficiency of the management and use of the water resources object of the concession. However, in practice, there are very few cases where authorities have reduced concessions permanently.

Alienation, access and extraction rights can only be transferred permanently from one user to another through a change in landownership. The total volume attached to a concession can be reduced by 50% during land transaction if the aquifer is declared over-exploited or the exploited groundwater body is at risk of failing WFD objectives. The 1999 Water Act allows concession holders to enter into contracts to temporarily transfer withdrawal rights to land other than stated in the concession to be irrigated.

Table 4 presents the procedures and requirements adopted in Spain around the five groundwater “rights”.

Table 4. Characteristics of groundwater rights in Spain

Type of right	Nature of right	Owner of right	Description
Access right	<ul style="list-style-type: none"> • A permit authorizing the construction of a well or borehole. • Valid in perpetuity. • Non revocable 	<ul style="list-style-type: none"> • Landowner, an irrigation organisation (“Comunidad de regantes”) or any petitioner accrediting that he has the agreement of the holders who met at least half of the surface of these lands 	
Withdrawal right	<p>Private historical water rights (granted before 1985 Water Law)</p> <ul style="list-style-type: none"> • No pumping limit for landowner, besides considerations on pumping distance among wells. • Valid in perpetuity. Non modifiable. <p>Concessions (granted after 1985 Water Law)</p> <ul style="list-style-type: none"> • Specifies a maximum annual & monthly volume that can be extracted, a maximum pumping flow rate; the intended use of water. • Valid for 50 years. Non revocable • Can be modified (reduced) in overexploited aquifers 	<ul style="list-style-type: none"> • Landowner, an irrigation organisation (“Comunidad de regantes”) or any claimant accrediting that he has the agreement of the holders who met at least half of the surface of these lands 	<p>Since 1986, all new prospective users required to obtain a permit</p> <p>Below 7000 m³ a year: no concession required</p> <p>Above 7000m³ a year: concession to be obtained from the river basin authority</p> <ul style="list-style-type: none"> • Some existing users have kept non-revocable but non-modifiable private extraction rights based on historical use • Some existing users have opted for revocable but modifiable permit <p>Concessions specify the maximum annual volume granted, maximum monthly volume where appropriate, and maximum instantaneous flow (m³/s), for a certain use</p> <p>Withdrawal right can be reduced if full allocation not used for more than three consecutive years (“use it or loose it”)</p>
Management right	<ul style="list-style-type: none"> • Right to set extraction limits, accounting for environment protection 	<ul style="list-style-type: none"> • RBAs, jointly with groundwater organisation user 	<p>The 1985 Water Act provided additional authority to RBAs to modulate access and withdrawal rights. The river basin management plans (“Planes Hidrologicos de cuenca”) can impose annual limits on withdrawal rights of both concession holders and private water right holders through groundwater abstraction plans (“Planes de Explotación”). The declaration of aquifer overexploitation, or of water bodies at risk of being at risk of not meeting WFD objectives, can result in stricter measures. Where the aquifer is declared overexploited or where water bodies are at risk of not meeting</p>

			WFD objectives, authorities can reduce concessions and private rights to meet the sustainable extractable volume. In that case, a groundwater user organisation has to be conformed within 6 months.
	<ul style="list-style-type: none"> • Right to design and implement specific measures in times of crises (drought) 	<ul style="list-style-type: none"> • RBAs, jointly with groundwater user organisation 	
	<ul style="list-style-type: none"> • Right to enforcing rules and apply sanctions 	<ul style="list-style-type: none"> • RBAs and Groundwater user organisations (GWUAs) 	<p>General cases: RBAs have enforcement authority to control groundwater uses and impose sanctions for illegal wells and excessive abstractions.</p> <p>Over-exploited basins: Groundwater user organisations can impose sanctions on their members (e.g. Mancha Oriental, Western Mancha)</p>
Exclusion right	<ul style="list-style-type: none"> • Right to declare basin closure (i.e. definition of overexploited aquifer/at risk of failing WFD objectives) 	<ul style="list-style-type: none"> • RBAs 	RBAs declare aquifers as overexploited.
	<ul style="list-style-type: none"> • Right to accept new agricultural users 	<ul style="list-style-type: none"> • RBAs 	<p>General case: no specific limit</p> <p>Overexploited aquifers: Authorities can block all new groundwater abstraction concessions</p>
Alienation right	<ul style="list-style-type: none"> • Right to transfer well authorisation, private right and concession during a land sell 	<ul style="list-style-type: none"> • General cases: landowners • Overexploited aquifers: landowners with RBA approval 	Water right remains attached to land ownership. Hence, the acquirer of a previously irrigated land obtains the associated water right. Irrigable land (land with irrigation rights) in Spain is more valuable than non-irrigable land. Where land is divided, the acquirer of irrigable land without access to a well can request a new access and withdrawal right as a public concession.
	<ul style="list-style-type: none"> • Right to sell a right to extract water (withdrawal right) 	<ul style="list-style-type: none"> • Landowners, with approval by RBA (within the basin) or by the Ministry (interbasin) 	

4.3 California

As in France and Spain, the right to build a well or obtain a well in California has historically been linked to landownership. Permits are required to build, modify, or deconstruct a well in California, and are issued by local counties. Moreover, a 2018 California court decision held that counties have a duty to consider the public trust before authorizing the drilling of groundwater wells that could adversely impact surface flows (a public trust resource).

Regarding groundwater withdrawal rights, there is no state permit system for withdrawing groundwater in California and landowners are generally not required to obtain a permit (Stanford University, 2020), unlike Spain and France. Importantly, groundwater use rights are implicit, until there is cause to define groundwater pumping rights such as in a court adjudication (see below). Therefore, in the absence of a court decree defining pumping rights or a local or a state regulation governing groundwater use, groundwater users can drill and pump water as they like.

Groundwater priorities of use have been developed through a relatively small number of California Supreme Court cases over many decades. Generally speaking, overlying landowners have priority to pump groundwater and put it to beneficial use without State or court approval. This right is a “correlative” or shared right meaning that all overlying landowners have equal rights to groundwater in the basin and, when there is insufficient water for overlying users, cutbacks are shared across users.

If the basin is deemed to have surplus groundwater, non-overlying users can claim appropriative rights, but they remain inferior to landowners’ rights. Appropriative rights are themselves prioritised according to level of seniority (prior-appropriation). However, a third class of rights, called prescriptive water rights, can realign these priorities, making it possible to obtain superior appropriative rights through prescription (Garner et al., 2020). A prescriptive water right is acquired through adverse possession of someone else’s water right (i.e. when the basin is in overdraft) when the use is actual, open and notorious, hostile and adverse to the original owner, continuous and uninterrupted for the statutory period of five years, and under a claim of right.

However, governance over control access and withdrawal rights has evolved over time, most recently culminating with the passage of California’s 2014 SGMA. SGMA requires prioritized basins to establish GSAs and develop GSPs that present measures to protect the basin from “undesirable” conditions, defined through “minimum thresholds” for specific parameters, such as aquifer levels. Under SGMA, any local public agency with water or land use responsibilities could form a GSA, including cities, counties, municipal water districts, irrigation districts, resource conservation districts, and water conservation districts. Local control was heavily emphasized in the legislation and gave basins the ability to form any number of GSAs so long as all areas within the basin were represented. This has resulted in the formation of more than 260 GSAs in over 140 basins (SWRCB, 2020).

In GSPs, GSAs can adopt a wide range of measures to achieve sustainability goals, such as rules and regulations on the creation of wells (e.g. spacing requirements), limits or suspension of groundwater extractions, measurement and reporting requirements, imposition of fees on groundwater extraction, enforcement and sanctions. Although GSAs are provided powers to control groundwater extractions, the legislation also states that decisions made under SGMA cannot determine or alter groundwater use rights. The implications of this seemingly contradictory language will likely need further interpretation, an action that will most likely play out in the courts (Babbitt et al., 2017).

SGMA presents a unique alternative framework to purely top down or bottom-up governance by empowering local agencies with the authority and responsibility to manage groundwater resources, with oversight and enforcement authority afforded to the state as a means to ensure sustainability goals are met (Kiparsky et al., 2017). The State Department of Water Resources is tasked with reviewing GSPs and plays a support role in SGMA implementation by providing statewide technical and financial assistance (e.g. grant programs and facilitation services) to GSAs.

The State has kept its intervention to the minimum, although it has created the possibility to intervene substantially if locals are unable or unwilling to sustainably manage their basin. The State Water Resources Control Board is authorized to step in to protect groundwater resources when a basin is designated “probationary” because the proposed GSP is unlikely to lead to meeting SGMA targets. In this way, state authorities work as a credible threat to local users: if they cannot compromise, the State may impose unwanted restrictions and can impose fees to recover the cost incurred in administering a probationary basin.

While SGMA is the state’s most comprehensive groundwater legislation passed to date, other authorities and laws developed prior to SGMA continue to have influence over control access and withdrawal rights across the state.

For example, prior to the passage of SGMA, the main institutional arrangements devised to regulate groundwater access and withdrawal could take different approaches (Langridge et al., 2016b). A particular type of district could be established to control some aspect of groundwater, for instance when a Water Replenishment District is authorized to establish a groundwater replenishment program. It could involve creating a limited purpose local government, known as Special Act District, authorized by the California Legislature and devised to respond to specific concerns, such as declining groundwater levels or degraded water quality. Finally, under the 1992 Groundwater Management Act (AB 3030) and supported by Senate Bill 1938 in 2002, groundwater districts could adopt management plans and take action to improve coordinated monitoring, operation, and administration of groundwater basins. Finally, since 2014, SGMA provides a comprehensive framework for managing groundwater.

Under SGMA, groundwater management plans in existence prior to January 2015, could be submitted as an alternative to a GSPs, pending approval of the State. Moving forward, only the 408 very low and low-priority basins not subject to SGMA can pursue voluntary groundwater management plans. Although voluntary in nature, such plans can enable a range of groundwater management efforts, from improving supply reliability through management and infrastructure (e.g. better conjunctive use of groundwater and surface water) to imposing controls on well creation and groundwater extraction.

Alternatives to a GSP could also take the form of a 10-year analysis (an analysis that demonstrates that basin has operated within sustainability limits over a period of at least 10 years) or a basin adjudication. An adjudication can be described as a process, mediated by a judge, to define the amount of water available to each user and can set controls on the creation of new wells, the further extraction of water and its exchange between users. In basins that have been adjudicated, groundwater use is subject to the specific court decree that has been issued. Court adjudications can cover an entire basin, a portion of a basin, or a group of basins (including non-basin locations between the group of basins).

While some adjudications quantified all allocations within the adjudicated area, other judgments do not actually quantify them (Langridge et al., 2016a). Given the complexity of defining groundwater use rights, California has a history of adjudicating groundwater rights, even though the process is almost always complex, expensive and lengthy, with many

adjudications taking decades to complete (Blomquist, 1992; Ayres et al., 2017; Langridge et al., 2016a).

Additionally, in California, city and county governments can leverage their “police powers” to implement groundwater management ordinances, including the monitoring and regulation of groundwater access and withdrawal, mainly through well registration and extraction statements (Enion, 2013; Babbitt, et al., 2018). While most ordinances originally focused on preventing out of basin transfers of water, more recently, counties have leveraged their authorities in an attempt to control groundwater use through limitations of well permits. For example, Sierra County in northern California put in place a permitting process for groundwater in 1997 and Ventura County and the City of Ojai, on the southern California coast, established ordinances prohibiting the issuance of permits for new water wells in unincorporated Ventura County in 2014 (Langridge et al., 2016b). It is not entirely clear the extent to which city and county governments can or will regulate groundwater in the future considering the passage of SGMA (Babbitt et al., 2018). In California, although no state-wide water market exists, water trading has long been an important water management tool (Hanak and Jezdimirovic, 2016). In several of California’s adjudicated basins, where water rights and priorities are defined, groundwater markets have also emerged. For example, the Mojave Basin Area adjudication allows for the temporary or permanent transfer of groundwater rights (known as an overlying landowner’s base annual production right) (Mojave Water Agency, n.d.). As groundwater basins work to achieve groundwater sustainability goals under SGMA, many basins facing overdraft conditions will need to consider ways to reduce the amount of groundwater pumped (e.g. demand management strategies) in addition to supply augmentation strategies (Jezdimirovic et al., 2020).

SGMA affords GSAs the authority to authorize temporary and permanent transfers of groundwater extraction allocations within their boundaries and several GSAs are considering setting up water trading programs that will allow landowners to market their groundwater allocations. GSAs are also exploring how crediting programs can help incentivize actions to recover groundwater levels, such as the permanent or temporary fallowing of land, on-farm recharge, private banking, and conversion to lower water-use crops (Babbitt et al., 2018). The Fox Canyon Groundwater Management Agency’s groundwater trading program in Ventura County (Heard et al., 2019), and the Rosedale-Rio Bravo water trading program in California’s Central Valley, are two early efforts to test water trading programs under SGMA (EDF, 2020).

Table 5 presents the procedures and requirements adopted in California around the five groundwater “rights”.

Table 5. Characteristics of groundwater rights in California under SGMA

Type of right	Nature of right	Owner of right	Description
Access right	<ul style="list-style-type: none"> Permits are required to build, modify, or deconstruct a well in California 	<ul style="list-style-type: none"> Landowners 	<ul style="list-style-type: none"> Counties have authority over well drilling permitting, well abandonment standards, and related health and safety concerns GSA's can adopt rules and regulations on the creation wells (e.g. spacing requirements)
Withdrawal right	<ul style="list-style-type: none"> There is no state permit system for withdrawing groundwater and landowners are generally not required to obtain a permit 	<ul style="list-style-type: none"> Landowners 	<p>Exceptions include:</p> <ul style="list-style-type: none"> SGMA – gives GSA's the authority to establish groundwater withdraw permitting regimes but does not require that they do so In certain instances, counties have leveraged their authorities in an attempt to control groundwater use through limitations of well permits. In an adjudication, courts define who the water right owners are and how much those rights holders can extract.
Management right	<ul style="list-style-type: none"> Depending on the specific circumstances, varying authorities and laws can afford authority to design withdrawal rules and ensure compliance. 	<ul style="list-style-type: none"> Depending on areas, local county, water agency or GSA, watermaster (under court order), 	<ul style="list-style-type: none"> SGMA enables GSA's to adopt a wide range of measures to achieve sustainability goals, including measurement and reporting requirements, imposition of fees on groundwater extraction, enforcement and sanctions. State intervention is possible if locals are unable or unwilling to sustainably manage their basin. County - The extent to which counties can or will regulate groundwater in the future is an open question in light of SGMA. If county groundwater ordinances conflict with management under SGMA, resolution of conflicts between GSA's and corresponding counties may be warranted. The Groundwater Management Act enables very low and low priority basins to voluntarily adopt Groundwater Management Plans to manage some aspects of groundwater Court adjudication - In basins that have been adjudicated, groundwater use is subject to the specific court decree that has been issued. The court typically appoints a watermaster to administer the court's decree.
Exclusion right	<ul style="list-style-type: none"> Depending on the specific circumstances, varying authorities determine who can access groundwater resources 	<ul style="list-style-type: none"> Depending on areas, local county, watermaster (under court order), GSA 	<ul style="list-style-type: none"> GSA – have the authority to limit or suspend groundwater extractions but cannot determine or alter groundwater use rights. Counties have direct land use authorities pursuant to their general police powers. In areas of critical overdraft, under certain conditions, counties could prohibit development without a demonstrable and sustainable water supply or adopt ordinances that coincide with and compliment the GSA's allocation authorities under SGMA In an adjudication, courts have the authority to define priorities and allocations among

			water users, including who the water right owners are and how much groundwater those rights owners can extract.
Alienation right	<ul style="list-style-type: none"> Depending on the specific circumstances, varying authorities can determine right to sell, lease and transfer rights to extract groundwater. 	<ul style="list-style-type: none"> Landowner 	<ul style="list-style-type: none"> GSA's have the authority to authorize (or restrict) temporary and permanent transfers of groundwater extraction allocations within their boundaries Counties have become concerned with potential mining of groundwater resources and have enacted ordinances prohibiting or conditioning exportation of groundwater from the county in which it was pumped. Some have even gone so far as limiting movement of groundwater from one subbasin to another within the county (Babbitt et al., 2018). Court adjudications can allow for the temporary or permanent transfer of groundwater rights

5 Discussion

5.1 Who controls groundwater access and withdrawals rights?

France, Spain and California share a common recognition that groundwater itself cannot be held privately. However, some notable differences can be observed over the right to access or extract groundwater.

In California and Spain, landowners hold the right to create a well, but, in both cases, permits are required, through local authorities in California and RBAs in Spain. These authorities can oppose the creation of a well or impose restrictions (e.g. well spacing). In Spain, the right to extract water from a well is further limited through the conditions set in concessions or the “registry of private water rights”. In California, individual limits on extractions may exist where the groundwater basin has been adjudicated. In the future, GSAs in California have the authority to establish on controls on well creation as well as withdrawal permitting regimes.

In contrast, France has adopted a very different approach in its permitting regime. All permits for well creation and for extracting water are revocable without compensation by the State. Furthermore, in priority basins, the right to extract water is transferred to the agricultural user organisation (OUGCs) (up to 15 years validity) and individual users are given one-year allowances by the OUGC. In this sense, France presents a more radical approach to empowering the user organisation, because the right to extract is not held privately anymore but collectively. The choice of the collective approach means France puts more emphasis on social preferences (and social justice) than efficiency, and more emphasis on flexibility than security of tenure. This may be related to lower water scarcity than in Spain or California.

These differences can also be partly explained from legal traditions. France has affirmed, in its 1992 Water Law, that groundwater is part of the common heritage of the nation, reinforcing the notion that water is held collectively. This has generally justified a shift towards watering down individual appropriative claims, as exemplified with the collective licensing of OUGCs and the use of annual allowances. By contrast, in their attempt to reach sustainability objectives, Spain and California have encouraged the definition of clear individual use rights. In Spain, groundwater users obtained non revocable, long term concessions (50 years) or perpetual private rights. In California, cases of adjudication led to the definition of individual rights to pump based on land ownership and historical use.

5.2 What role for the State and users’ organisations?

In the three cases, the State retains power concerning the identification and delineation of priority groundwater basins where extraction needs to be further regulated and water users’ organizations must be established. However, the comparison of the institutional arrangements developed in the three case studies to support comanagement clearly show that authority over the design and implementation of rules on how groundwater can be accessed and extracted can be shared between the State and users in very different ways (Table 6).

Concerning the definition of sustainable extraction limits, users’ organisations are left with little room for manoeuvre in France and Spain. The State plays a key role in defining

minimum groundwater level thresholds that should be maintained to ensure long term sustainability of aquifers and dependent ecosystems. In both countries, the State also imposes how sustainability should be reached, by setting restrictions on water use, based on the definition of volumetric extraction caps from the aquifer to individual user level. By contrast, California has adopted a more decentralized approach where users organization (GSAs) have a more freedom to define targets for groundwater levels as long as they can demonstrate that they take the necessary measures to meet SGMA sustainability objectives. Until now, volumetric caps and individual allocations have not been considered by most GSAs (Jezdimirovic et al., 2020), despite several existing in adjudicated basins and Special Act Districts (Stanford University, 2020).

Regarding decisions on allocations and reallocations in priority basins, a top-down approach prevails in Spain as most decisions are taken by RBAs based on claims from existing and prospective users. User organisations (GWUAs) cannot directly modify pre-existing concessions, but RBAs can revise concessions, for instance when a user repeatedly does not use its full allocation (i.e. use-it-or-lose-it). During droughts, restrictions usually apply proportionally to all users. This is in contrast with France who has opted for a decentralized approach, in which local user organisations (OUGCs) are entrusted with the responsibility to define locally negotiated collective rules to apportion the available resource among their members. Thus, each OUGC have its own set of rules to allocate water between recognized users. OUGCs also choose the criteria determining which new members can be admitted as well as rules for reallocating the resource among members.

In California, adjudications in courts were in most cases merely a means to validate locally negotiated agreements (Langridge et al., 2016a). A watermaster is then typically appointed to adjudicated basins, and has a role in apportioning the water available in any specific year based on the defined adjudicated rights of use. Building on experience from water districts, most GSAs plan to use a combination of water imports, replenishment, and economic instruments (e.g. extraction fees, crediting programmes) to influence more indirectly allocations between appropriators (Jezdimirovic et al., 2020).

Last but not least, significant differences are observed concerning compliance and enforcement. In Spain and California, user organisations are entrusted with the authority to control and sanction non-complying users, while the State in France has kept that authority, and the user organisation (OUGC) is only involved in monitoring groundwater extraction by users.

The difference in approach regarding state and local control between California, France and Spain is likely due to a combination of cultural, political and historical factors. For instance, California has a unique historical commitment to local control in an effort to keep groundwater out of state control, as opposed to surface water (Dennis et al., 2020). Thus, prior to 2014, the State has limited its support for groundwater management to providing scientific and technical assistance, granting powers for local action, and facilitating groundwater management planning. With SGMA, it has moved from enabling and incentivizing local groundwater management, to a position of “mandating” local action (Dennis et al., 2020).

In France and Spain, by contrast, the State has traditionally a strong regulatory role and a legal commitment to manage water resources according to EU WFD environmental objectives. The establishment of user organizations to “co-manage” groundwater overexploitation is the

result of a gradual process of involving users in water management decisions, that started in the 1960s notably with the establishment of stakeholder committees in river basin organisations.

Table 6: Role of the State and user organisations in the three cases

Type of decisions	France	Spain	California
Establishment of users' organisation in priority basins	Imposed by the State	Imposed by the State (RBA)	Imposed by the State
Definition of sustainable extraction limits	State, based on EU WFD requirements and stakeholder consultation	State (RBA), based on EU WFD requirements and on stakeholder consultation	User organisations (GSA), based on SGMA objectives Court in case of adjudications
Allocation of water to users	User organisation (OUGC), validated by State	State (RBA), based on concessions and private rights	User organisation (GSA) Court in case of adjudications (judiciary)
Long term reallocation (e.g. between existing users, new entrants)	User organisation (OUGC), validated by State	State, based on consultation with user organisation (GWUA)	User organisation (GSA) Court in case of adjudication Water districts, through replenishment programs and economic instruments
Compliance and enforcement	State, based on monitoring by State and user organization (OUGC)	User organisations (minor infractions) and State (major infractions)	User organisations (GSA) and State (as backstop) Court in case of adjudications Water district through replenishment programs and economic instruments

5.3 The risk of regulatory capture and the need for “credible threats”

Comanagement should go beyond mere consultation and participation of stakeholders, moving up Arstein's ladder (Arnstein, 1969) towards shared decision-making powers and effectively devolving responsibilities to non-state actors. For many scholars, it is about empowering users and community groups to “self-regulate”, for instance by devolving policing powers to local groups (Ostrom, 1990; Wester et al., 2009, 2011; Molle and Closas, 2020a). In this sense, California and Spain have gone further than France, empowering groundwater user groups to monitor and impose sanctions on its users. In France, the state has kept these powers.

However, comanagement entails risks. One such risk is that users cannot agree on the sharing of the burden in reducing over-extraction or only agree on sub-optimal outcomes in particular regarding environmental effectiveness and social justice (Schlager, 2007). In France, OUGCs have usually rolled in pre-existing individual extraction permits into the initial OUGC allocation plan, in a form of prior-appropriation, and many opted for less ambitious reallocation

rules (Rouillard and Rinaudo, 2020). With its long adjudication processes (often decades), California has shown the difficulty for groundwater users to agree on an allocation formula (Bloomquist, 1992). Negotiated outcomes have often been at the expense of environmental uses and have favoured large groundwater users over smaller ones and disadvantaged communities (Langridge et al., 2016a). GSAs are also at risk of such power imbalance (Méndez-Barrientos et al., 2020).

To mitigate these risks, scholars have argued for institutional checks and balances on e.g. policy formulation, interpretation of the rules, adjudication and enforcement. If users are involved in the definition of spatial and temporal extraction caps (i.e. management rights) but fail to agree on, or implement, ambitious caps, then “credible threats” are needed from higher authorities to ensure users adopt measures leading to sustainable outcomes (Molle and Closas, 2020a). Higher level jurisdictions may provide support to accompany the negotiation and mediate conflicts (Moran et al., 2019) or may intervene to impose more ambitious measures.

In the three cases, authorities have adopted regulatory tools to intervene in the most over appropriated groundwater basins, which suggest a commitment to tackle the most problematic cases. In France, authorities can intervene if OUGCs do not agree on an allocation formula or an appropriate ramp down of individual allocations to reach extraction caps. In Spain, authorities can intervene to impose an allocation plan in overexploited aquifers. SGMA has introduced the possibility for the Californian authorities to step in to protect groundwater resources when the proposed groundwater sustainability plan is unlikely to lead to meeting SGMA objectives.

While recent years have seen much activity with setting up new institutions to meet WFD objectives (in Spain and France) and SGMA (in California), it remains to be seen whether authorities remain committed to the full implementation of, and compliance to, sustainability standards enshrined in the legislations. The capacity and willingness of the State to enforce environmental standards is fragile to changes in political and economic conditions. There is also the risk of “regulatory capture” which is a situation where the relationship between the regulator and the regulated is too close and threatens the environmental effectiveness and the fairness of negotiated outcomes (Lopez-Gunn and Cortina, 2006). In France, the setting of volumetric extraction caps is an outcome of a participative process, which has so far resulted in generous user allocations at the expense of meeting environmental requirements (Arnaud, 2020; Rouillard and Rinaudo, 2020).

In Spain, the experience has proved that an allocation plan is not always sufficient, as enforcement can be an issue. The threat of taking actions by imposing a more restrictive allocation plan has worked in certain places (e.g. Eastern Mancha) by encouraging local actors to adopt stronger control on water use. However, when users oppose any mediation or compromise, regulatory bodies need to impose credible threats of sanctions and groundwater access limitations, as in the case of Western Mancha. Closas et al. (2017) analyse several particularities of this system organisation that help to explain the failure of collective action and the poor co-management, such as a large aquifer size and a large number of users, the politization and lobbies within the farmer organisation, and policies lacking ambition.

Ultimately, the effectiveness of comanagement will rest on the commitment of the State to enforce sustainable solutions, but also on the legitimacy of management decisions and their adaptation to local circumstances, and ultimately on users supporting the new environmental standards. This underlines the importance of establishing not only institutional checks and

balance across governance levels (e.g. through credible regulatory threats), but also processes of trust building and social learning between state actors and users to ensure a common understanding of the need to regulate water use and how to do so.

6 Conclusions

The paper has examined the definition, exercise and sharing of groundwater rights in France, Spain and California, and shed light on the differing institutional mechanisms influencing the allocation of groundwater between agricultural users. The three cases show an evolution towards greater oversight over operational rights of accessing and withdrawing groundwater, and greater collective management between authorities and groundwater users. Overall, the State in France, Spain and California share a similar overarching role: it delineates priority groundwater basins, imposes the establishment of user organisations, and may intervene if sustainability objectives are not met. France and Spain maintain a stronger role in setting the overall allocation framework, by regulating water use through public permitting regimes and defining sustainable extraction caps. However, France transfers more responsibilities to users organisations when it comes to define who legitimate users are and how much water they should be entitled to receive, while Spain and California grants more authority to user organizations in compliance and enforcement. Each case will face unique challenges when implementing comanagement. For instance, French user organization may find their legitimacy compromised due to a lack of authority over non-complying users. By contrast, Californian authorities may face significant challenges in intervening on non-complying GSAs. As the implementation of the EU WFD in Spain and France and SGMA in California advances, future work should assess more closely the performance of each of these unique comanagement arrangements.

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