Chapter 3
Groundwater Policy in France: From Private to Collective Management

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Abstract According to 1804 French Civil Code, groundwater is considered as a private property. However, after this resource started to be intensively exploited by industries in the 1850's, the State increasingly regulated its use. In 1935, a system of individual access and withdrawal rights, managed by the State, was established to protect deep confined aquifers which were showing signs of overexploitation. This system of use right was later on extended to unconfined shallow aquifers with the 1992 water law, mainly to protect the environment. A new management approach, based on individual volumetric entitlements, was then developed and tested in several French groundwater basins, subsequently obtaining a legal basis in the early 2000's. The 2006 water law constitutes a clear break in French water policy. The system of individual volumetric entitlements managed by the State was cancelled and users asked to form Water Users' Associations at the catchment level. Associations became the recipients of pooled water use entitlements, which they must share among their members using rules agreed collectively. Although this reform only applies to the agricultural sector, its represents a clear shift from a private to a common property regime.

Keywords Allocation policy · Private property · Common property · Users' associations · Water trading

3.1 Introduction

In France, as in other Latin countries, groundwater has long been regarded as *Res Nullius*, i.e. it has no master and is subject to private appropriation by those who own the land that overlies the resource. This principle was enshrined in law as of

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1804 (articles 552 and 641 of the civil code) and remains unchanged to this day. Groundwater use has developed in the context of this unrestrictive institutional framework (Gazzaniga & Larrouy-Castéra, 2010; Guttinger, 1992).

Until the mid nineteenth century, groundwater use remained limited to spring-water catchments or abstraction through drainage tunnels to supply large cities (e.g. Paris, Nancy). With advances in hydrogeology and drilling technologies, confined aquifers were developed progressively, particularly for industrial activities in the north of France and the Paris Basin. However, the proliferation of boreholes caused a rapid decrease in potentiometric levels. As a result, the State regulated access to deep aquifers with the publication of the first legislation, the 1935 Water Act.

From the 1950s onwards, the development of drinking-water supply systems led to a new wave of borehole construction that provided water of a better overall quality and reliability than streams. This development was facilitated by the rural code, with the aim of developing and improving living standards in the countryside.

Following the severe drought of 1976 and subsequent droughts in the late 1980s, agriculture joined the race to exploit groundwater resources. Thousands of boreholes were drilled on farms for the development of irrigation, primarily from easily accessible unconfined aquifers. The increase in agricultural abstraction sometimes had a significant impact on aquatic ecosystems, causing springs to dry up, the draining of wetlands, and the reduction of water levels in rivers and streams during low-flow periods. This urged the State to intervene once more with the 1992 Water Act, which laid the foundations for a quantitative management policy. In 2000, the European Water Framework Directive strengthened the protection requirements for aquatic systems, which led to the new 2006 Water Act.

This chapter provides a detailed chronological description of the changes. Above all, it describes the type of regulatory tools implemented, their limitations and their gradual improvement. We also analyse how the State has progressively restricted owners from exercising their rights in order to protect public interest, which was continually redefined over time. In addition, it shows how the State has gradually involved users in the process of groundwater management.

3.2 Protecting Deep Aquifers for the Public Good

3.2.1 Science Discovers How Groundwater Flows

The art of capturing springs and channelling water by gravity to large cities goes back to ancient times, as shown by the numerous aqueducts that date from the Roman era in France. However, a scientific approach to groundwater and how it flows through aquifers did not actually emerge until the nineteenth century, along with the development of drilling techniques to capture groundwater.

The first hydrogeological theoreticians and practitioners in France were engineers, including Arago, Belgrand, Dausse and Darcy, who were interested in the establishment of urban drinking water supply systems. These pioneers of hydrogeology observed and attempted to explain the variations in groundwater levels. The foundation of quantitative hydrogeology was the derivation of Darcy Law (1856), which Dupuit applied to the flow of water in aquifers 10 years later.

In parallel, the techniques for drilling at greater depths also progressed, partly due to advances in the understanding of geology and the structure of sedimentary basins. The first deep boreholes were drilled in Tours, Lille and then Paris where the Grenelle artesian borehole was sunk between 1833 and 1841. It was 548 m deep, with an artesian flow rate of 160 m^3 per hour. The number of deep boreholes in the major sedimentary basins soon increased, primarily for industrial supplies.

It was not until the beginning of the twentieth century that scientists began working on a national survey of groundwater resources (Margat, Pennequin, & Roux, 2013). In 1909, E. Imbeaux presented the first description of the "aquifers of France" to the French Geological Society, followed by a series of regional hydrogeological monographs in 1930. The first potentiometric maps were compiled for the Somme area in 1933. Lemoine, Humery and Soyer (1939) published a comprehensive inventory of the deep boreholes in the Paris Basin in 1939, which was a prelude to the databases that exist today. The first map of the groundwater resources of France only became available in 1964, with a detailed atlas following in 1970.

3.2.2 The First Regulation: The 1935 Water Act

Parallel to the advances in knowledge, the use of deep groundwater spread rapidly throughout France with abstraction from deep aquifers rising from 60 to over 300 million m^3/y in the first half of the twentieth century. The same phenomenon occurred in the French colonies of North Africa (Margat et al., 2013).

This resulted in a rapid drop in pressure in several deep aquifers, which triggered state intervention to regulate groundwater use. With the Water Act of 8 August 1935, the State introduced a procedure prohibiting the construction of wells and boreholes exceeding a depth of 80 m without prior authorization. This allowed the State to prevent further abstraction from overexploited aquifers. The permits granted to existing users were not subject to alteration, which amounts to recognising historical rights. In contrast, the permits were not transferable.

The aim of the regulation was obviously not to protect water-dependent ecosystems, but, instead, it set out to avoid depleting a resource that was clearly perceived as a strategic asset for the Paris region and to ensure that industrial use remained compatible with the necessity of supplying drinking water to a growing population in the future.

The 1935 Water Act therefore primarily focused on controlling abstraction in the industrial sector. Agricultural use was not affected, given that irrigation relying on groundwater was virtually non-existent until the early 1960s. The law also did not apply to boreholes used for supplying drinking water, which were authorised by a different procedure, namely the declaration of a public utility in accordance with article 113 of the former rural code. The supply of drinking water was already regarded as a high-priority use, which served the public good.

3.2.3 Extending the Scope of the Water Act: 1935–1985

For 50 years, the 1935 Water Act was the only regulatory tool available for managing groundwater abstraction. It initially targeted three counties in the Paris region, but was subsequently applied to seven other counties over a 50-year period, with slightly different procedures Fig. 3.1).

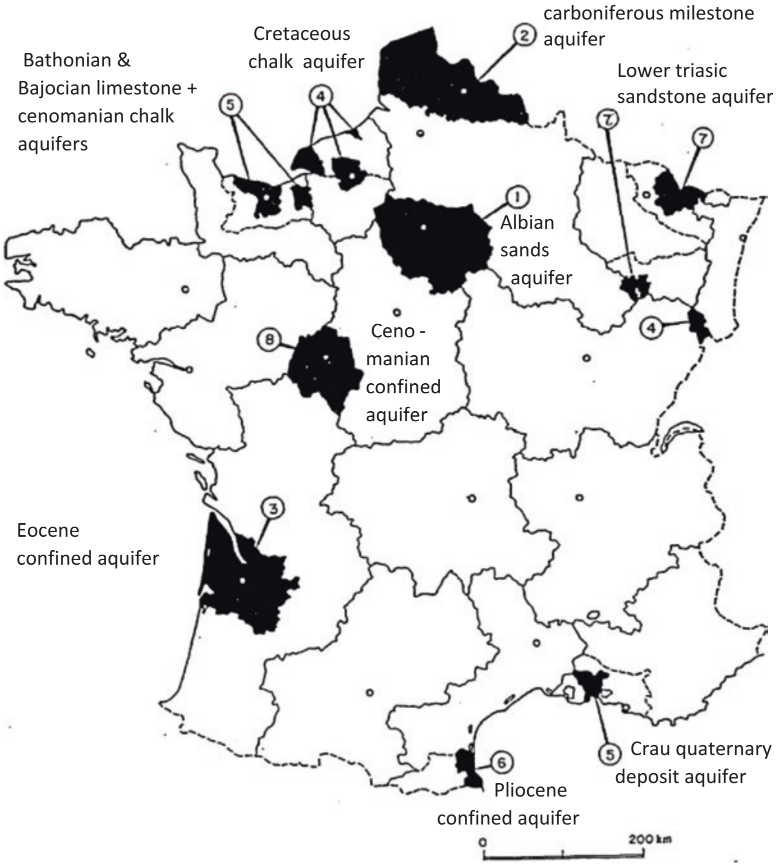
Gradual application of the law to other counties coincided with an endeavour to improve knowledge of the groundwater resources. In the late 1950s, the State developed a network for monitoring pressure levels in the deep aquifers of northern France, the Paris Basin, and the Aquitaine Basin. It also encouraged the development of mathematical models designed to assess the impact of pumping scenarios. In the late 1960s, the first mathematical models were developed for the most significant confined and alluvial aquifers. (Margat et al., 2013).

The effectiveness of policies implemented under the 1935 Water Act varies from region to region. In the Paris region, the measures applied made it possible to stabilize and later partially recover previously declining water levels in the Albian greensands aquifer (Fig. 3.2). In some counties, the legal provisions were not strictly applied because of insufficient resources allocated to law-enforcement activities. In other counties, abstraction continued to increase even though the number of boreholes was controlled (e.g. the Gironde aquifers). In the Nord Pas de Calais region, the legislation only had a limited impact on the Carboniferous limestone aquifer because no restrictive measures covered the Belgian section of this cross-border aquifer. In the Roussillon region, many deep boreholes were drilled for agricultural purposes without authorisation.

3.3 The Emergence of an Integrated Approach to Surface and Groundwater Management

3.3.1 The Development of Groundwater Use in Agriculture

The 1935 Water Act deliberately excluded abstraction for agricultural purposes from its provisions because, at the time, the volumes were very limited compared to other uses. However, since the 1960s there has been major growth in irrigation using shallow groundwater and, to a lesser extent, deep aquifers. Many boreholes were drilled in the cereal-growing plains in central and western France, where access to groundwater made it possible to increase yields and diversify production (Martin, 1972). Following the droughts of 1976, 1985–86 (Ollivier, 1989) and 1988–89



	Region or counties	Date	Authorisation required:
(1)	*Paris Region: 8 counties*	1935	If depth > 80m
(2)	*Nord Pas de Calais*	1958	If depth > 80m or if pumping rate < 250 m3/h and depth > 5m
(3)	*Gironde county*	1959	If depth > 60 m
(4)	*Seine Maritime & Territoire de Belfort*	1973	If depth > 80m or if pumping rate > 8m3/h and depth > 10m
(5)	*Bouches du Rhône & Calvados*	1973	If depth > 80m or if pumping rate > 8m3/h and depth > 2m
(6)	*Pyrénées Orientales*	1973	If depth > 80m or if pumping rate > 8m3/h and depth > 30m
(7)	*Moselle & Vosges*	1981	If depth > 80m or if pumping rate > 8m3/h and depth > 40m
(8)	*Indreet - Loire*	1985	If depth > 40 m

Fig. 3.1 French counties where the 1935 Water Act restricting groundwater use was applied between 1935 and 1985

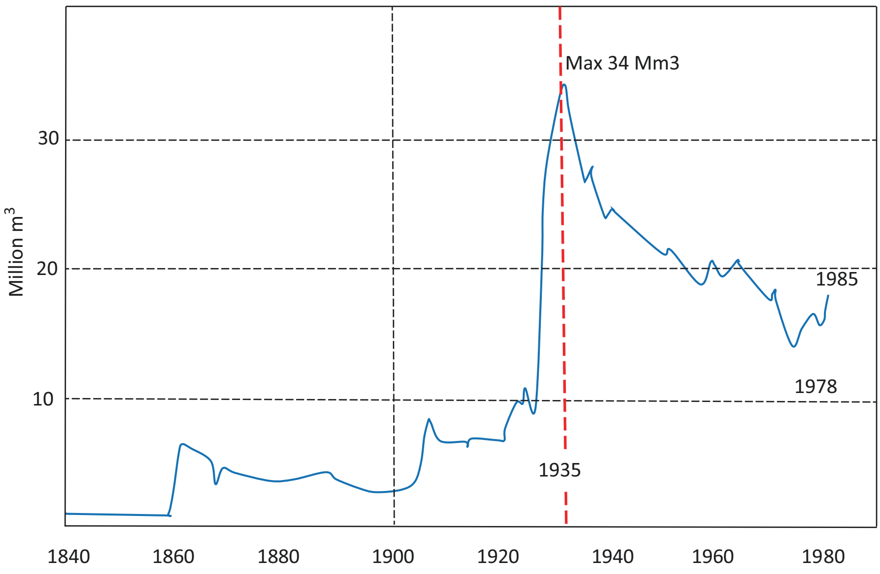


Fig. 3.2 Groundwater abstraction (m^3/year) in the Albian greensand aquifer in the Paris region. (Adapted from Risler and Roux, 1993)

(Merillon & Chaperon, 1990), numerous farmers installed boreholes as a safeguard against the risk of drought. This development was encouraged by public funding through Common Agricultural Policy incentives until 1992 (see Chap. 24), as well as by food-processing stakeholders in some sectors (especially maize production). The phenomenon was particularly common in western and central France (Loubier et al., 2013).

As most agricultural boreholes were shallower than the limit imposed by the 1935 Water Act, the regulatory provision for them merely stipulated that boreholes must be declared under the Mining Code if their depth exceeds 10 m.[1] The only main constraint likely to limit the volume abstracted by each user was yield characteristics of the various aquifers.

In 1964, a new water law was passed, establishing water agencies (Barraqué et al., 2018) and several provisions related to water use. It required that water abstraction be declared if the borehole flow rate exceeds 8 m^3 per hour but this provision did not alter this virtually unlimited access to shallow aquifers. It also introduced a water abstraction tax but its level was too low to represent an economic constraint likely to limit groundwater use, which continued rising.

In some regions, the development of agricultural wells and boreholes was such that it lowered groundwater levels, which in turn caused some springs to dry up and drained watercourses and wetlands. The environmental impacts created tension with people who used watercourses for recreational purposes (e.g. fishermen) and

[1] Apart from several counties, where a preliminary authorisation is required beyond a certain depth (50–80 m) pursuant to the Water Act of 8 August 1935.

environmental-protection groups. This prompted the State to gradually strengthen the legal and regulatory framework.

The law of 1984[2] provided a preliminary response to the social demand, claiming that "*the preservation of aquatic environments and fish habitats was in the public interest*". In practice, this principle led to the establishment of environmental flow for watercourses. The administration was given the power to restrict the abstraction of surface water when environmental flow was not being maintained. The restrictions were in the form of water rotations, whereby the irrigators had to irrigate successively (by geographic sector) with a weekly time period that became shorter and shorter. The law only applied to surface-water abstraction. Thus it failed to resolve the conflicts in catchment areas where low river flows were declining due to the overexploitation of connected alluvial aquifers. The 1989 drought clearly revealed the weaknesses in the regulations (Merillon & Chaperon, 1990).

3.3.2 Water Becomes the Heritage of the Nation (1992)

The 1992 Water Act marked a major shift in the policy for water-resource management. While it did not fundamentally negate the right of landowners to abstract groundwater, it included several provisions that severely restricted the ability of landowners to exercise this right.

The first provision consisted in establishing a declaration/authorisation system[3] applicable to all water use (for volumes exceeding 8/80 m^3/h, respectively). The installation of a water-metering device became obligatory at each abstraction point and users were also required to keep a quarterly record of the volumes abstracted. In addition, the law introduced the possibility of lowering the authorisation thresholds to 8 m^3/h in areas considered to have extraction exceeding recharge. These were known as Water Restriction Areas (Zones de Répartitions des Eau or ZREs). In the ZREs, the State could also prohibit the construction of new boreholes. Extraction for the agricultural sector was now directly brought under State control.

The second provision of the water act underlined the uniqueness of the water resource, i.e. that groundwater is an integral part of the water cycle. The legal distinction between surface and groundwater resources, inherited from Roman law and formalised in the Civil Code, became less apparent with the emergence of a more holistic vision of how aquatic environments and water resources interact. Henceforth, the State could legitimately impose restrictions on groundwater use, which earlier had not been possible, and thus substantially weaken groundwater ownership rights. It is important to note that the legislative changes in France reflected the reforms that were being introduced in other European countries at the same time, especially in Spain with the 1985 legislation and Portugal with the 1994 legislation (Barraque, 2004).

[2] Law n° 84-512 of 29th June 1984 relating to freshwater fishing and the management of fish resources. Journal Officiel de la République Française, n°30 June 1984, France, p. 2039–2045.

[3] The 1935 Water Act was repealed and replaced by the 1992 Water Act.

The third provision imposed the development of water-management plans on a catchment scale, requiring the creation of Local Water Management Plans (Schémas d'Aménagement et de Gestion des Eaux or SAGEs). The plans are established in consultation with the stakeholders in order to reconcile the demands of different water users and to maintain the quality of the aquatic environments (see Chap. 4). For quantitative water-resource management, particularly groundwater, the plans had to restore the balance between use and the available resources by modifying or withdrawing certain abstraction permits where necessary. The law specifies that, when required, permits can be withdrawn or modified without State compensation, for guaranteeing drinking-water supplies or for protecting aquatic ecosystems.

In this way, quantitative management planning was introduced in several catchment areas where groundwater was a major component. The approach involved defining the groundwater-level warning indicators, which, when exceeded, triggered measures to restrict water use (to the possible extent of a total ban). Therefore, it extended the scope of the surface-water provisions of the 1984 act to include groundwater. Indicators of this type were established in many regions to manage both confined and unconfined aquifers. This is illustrated by the case of the Beauce aquifer (Chap. 5), the aquifers in the south of the Vendée with respect to the Poitevin marshes (see Chap. 18), the Rochefoucauld karst in Poitou Charentes and the Albian aquifer (Seguin et al., 2009). Figure 3.3 shows the location of ZREs in 2017.

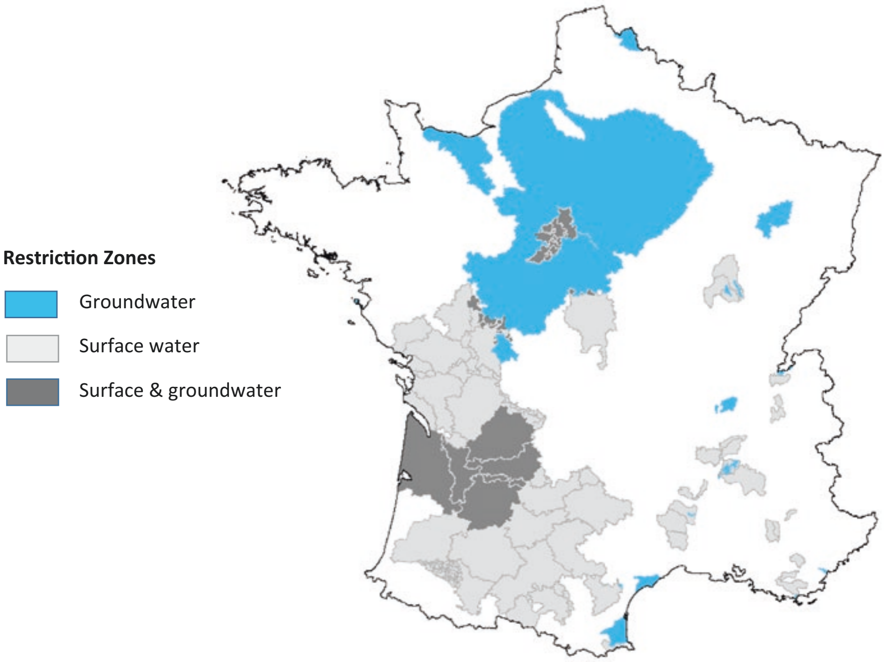


Fig. 3.3 Surface- and groundwater use Restriction Zones (ZRE) in 2017

3.3.3 The Problems of Implementation

Applying the provisions set out in the 1992 Act to groundwater was not an easy task (Compte et al., 1995). The State lacked the means to enforce irrigation restriction measures, to check the installation and accuracy of meters, to monitor the abstraction registers as laid down by law, or even to control the pumping capacities (see Chap. 23). A 1996 Parliamentary report stated: "*It is clear that the texts relating to groundwater policing are not being applied, far from it, and implementing them would require staff that the administration does not seem to have*" (Martin, 1996). The requirement for meters was not well received by the agricultural community and consequently they were installed much later than the deadlines set out by the Act, particularly in the Adour Garonne Basin. A large number of abstraction boreholes was not declared. This situation persisted locally until the mid-2000s (Brun, 2003; Montginoul & Rinaudo, 2010). The administration gained additional leverage following the 1999 Common Agricultural Policy reform that introduced the principle of cross-compliance, which made direct payments to farmers dependent on their compliance to install water meters (Chap. 24).

3.4 Towards Volumetric Management

3.4.1 The Emergence of Volumetric Management

The limitations of management based on water-level indicators soon became apparent when two adverse impacts were observed. First, when groundwater level falls and approaches the warning threshold, farmers increase their irrigation to build up soil moisture reserves, resulting in further reductions in groundwater levels and a waste of the resource. Second, to overcome the effect of restrictions on the time period for irrigation, farmers invest to improve their irrigation capacity so they could irrigate all their land in a shorter time, resulting in no reduction in the quantity of water abstracted. Both responses accelerate the rate of abstraction, hasten the onset of a crisis during the irrigation season and increase the frequency of such crises. Therefore, the risk of a water shortage (and the associated agronomic and economic implications) remains high and difficult for farmers to predict and plan for.

In the late 1990s, this failure led to several managers adopting a new approach: volumetric management. This involves capping the total volume that can be abstracted from groundwater resources that are deemed to be overexploited, and dividing it between the users in the form of individual abstraction quotas. As each farmer has access to a set volume for the whole irrigation season, they were encouraged to manage their water use efficiently to maximise their economic return.

In most cases, the total abstraction limit was initially established on the basis of resource use at the time of the reform ("grandfathering"). The objective was only to prevent any new increases in abstraction that might have adverse impacts on the resource and not to align use with recharge. In the case of the Beauce aquifer, the quotas negotiated by the agricultural water users in 1998 corresponded to the maximum volume used over the last decade (Chap. 5; Bouarfa et al., 2011).

The advantage of this volumetric approach is that it reduces uncertainty for the irrigators, while giving them greater responsibility for managing their annual volume. In addition, the system may allow the irrigator to carry forward the unused volume from one year to the next. This encourages farmers to improve the technical and economic efficiency of their water use. This inter-annual transfer is only possible if the aquifer is robust (if the ratio of available water storage over annual recharge is high). Such volumetric management was introduced towards the end of the 2000s in several catchment areas and counties.[4]

3.4.2 Individual Appropriation of the Resource

The introduction of volumetric management had a paradoxical effect on groundwater ownership. Initially, it weakened the landowners' right to freely use the groundwater located beneath their property because it capped the volume used. However, by limiting the total usable volume, the new management system created a situation of shortage, which increased the value of the water quota.

Farmers did everything within their power to ensure that the individual volume allocated to them was tied to their farm as a way of enhancing the value of their landholding. They managed to persuade the State agencies to transfer the quotas from the previous to the new owner when farms were sold, instead of reallocating the water to the newcomers registered on a waiting list. This transfer occurred not only in the case of family successions, but also in the case of a sale of the whole farm (land, machinery, buildings) to a third party. From then on, the income associated with quotas was built into the value of the land. Although a farmer who transfers his volume (or quota) cannot officially receive financial compensation from the new beneficiary for transferring the authorised volume, he actually recovers its value by selling his farm at a high price. By tolerating this practice, the administration contributed to a situation where the first groundwater users who received free permits, ended up appropriating the economic rent associated with groundwater.

Various discussions in the 1990s show that the idea of private appropriation of water resources was already very clear in people's minds. Several French economists debated the possibility of formalizing the market for exchanging individual water quotas through a proposal that involved decoupling the rights to use a resource from land ownership, thus creating a market where they could be traded freely (Kosciusko-Morizet et al., 1998; Strosser & Montginoul, 2001). At about the same

[4] The main examples are the Beauce aquifer, the Yèvre-Auron Basin (Cher county), the alluvial aquifers in the plains in Garonne-Tarn-Aveyron and Ariège, the Sud-Vendée aquifers, Vienne county, Charente county, and in the catchments located in the counties of Aisne, Aube, Somme and Sarthe.

time, experiments were being conducted on “water banks” in western U.S. states following the 1989–91 drought, and Australia adopted the proposal in its draft water reform policy of 1994 (see Chap. 21). This proposal continued to spark debate in France for a decade (Petit, 2004; Rinaudo, 2014), but was never implemented, the State considering that “*the transfer of this type of system [from Anglo-Saxon countries to France] is not desirable in France because it is contrary to our concept of water, which goes beyond that of a purely economic good*” (Conseil Economique et Social, 1991).

3.5 Towards Collective Management

In March 2000, the European Water Framework Directive (WFD) came into force. It obliged member states to take all the necessary action to ensure that water resources and associated aquatic ecosystems were restored to a satisfactory qualitative and quantitative state within 15 years. This imperative to achieve results put pressure on the French State to review its legislation. First of all, the directive was converted into French law (the law of 21 April 2004), and then in 2006, a new law for water and aquatic environments was passed that aimed at providing France with the necessary tools for achieving the satisfactory state in 2015, as set out by the WFD.

3.5.1 The 2006 Water Act

The 2006 Water Act[5] introduced a major change with regard to water distribution among users and enhanced the rationale of volumetric management.

One of the law’s main provisions concerning quantitative management was the obligation to restore a balance between abstraction and the available resources for all catchment areas (surface- or groundwater) considered to be overdeveloped. The administration was responsible for assessing the maximum abstraction volume, which ensured that the environmental goals were achieved in at least 4 years out of 5.[6] The authorised abstraction should not exceed this maximum volume. The studies on the maximum volumes to be abstracted generally concluded that it was necessary to reduce abstraction by 10–20% in most catchments and by over 50% in some cases (Chap. 11). The reductions were to be achieved with no financial compensation.

The law also redefined how the maximum volumes to be abstracted should be shared amongst the existing users. Drinking-water supplies were considered a prior-

5 Law n° 2006-1772 of 30th December 2006 on water and aquatic environments, Journal Officiel de la République Française, n° 303 of 31 December 2006, France, Text n° 3/175.

6 The volume to be abstracted is defined in the circular of 03/08/2010 and available online at: http://circulaire.legifrance.gouv.fr/pdf/2010/08/cir_31709.pdf

ity and operators received a volume corresponding to a technically efficient supply for the demand. The remaining volume was shared between the industrial sector (which often had few users) and the agricultural sector. Given the large number of farmers, the State allocated the responsibility of sharing the volume designated for farming to an intermediary institution named Organisme Unique de Gestion Collective or OIUGC (Unique Collective Management Organisation). This OUGC is an agricultural water user association that was made obligatory in the 2006 Water Act (Figureau et al., 2012; Lafitte et al., 2008). From a regulatory point of view, the State cancelled all individual water use permits previously granted to each farmer and replaced them with a single aggregate permit that was attributed to the OUGC.

The OUGC was made responsible for preparing a plan to allocate the total volume between the users. This involved devising its own set of management rules, which had to be validated by the administration. For example, the allocation rule had to include admission procedures for newcomers, the priority rules in the event of drought, etc. This provided the basis for the annual allocation scheme, which is approved by the State each year. The rationale underlying this transfer of responsibility is that the users, brought together in the OUGC, are the best placed when it comes to adjusting water sharing among farmers and accounting for the local technical and economic circumstances.

3.5.2 Gradual and Differentiated Implementation

In practice, the “quantitative management” component of the 2006 water law met with considerable opposition on the part of the farming profession, particularly in south-western France (Hébert et al., 2012). Some farmers perceived the pooled allocation as a form of expropriation and were quick to make the parallel with agricultural collectivization in Russia in the early 1920s. The feeling was heightened by the fact that, almost invariably, they had invested individually to access the resource.

The sustainable extraction limits (specifying the maximum volumes to be abstracted) were also challenged because of doubts surrounding how they were estimated. The values that were ultimately agreed upon were negotiated on economic and political, rather than scientific, grounds (see Chap. 11). In some basins, the negotiation also allowed the agricultural users to obtain public subsidies to finance the construction of reservoirs for storing surface water or groundwater abstracted in winter when it is more abundant, for later use in summer. The allocation of public subsidies represented an implicit compensation for the reduction in the volumes to be abstracted.

At the end of 2016, about 30 OUGCs had been established and they started applying their allocation rules for the first time in 2017. A preliminary analysis of the new rules highlights the diversity of the different approaches adopted by the OUGCs. The differences concern the identification of beneficiaries—the farmers who can legitimately benefit from access to the water resource—and the criteria used to determine the share of the volume that each beneficiary can claim.

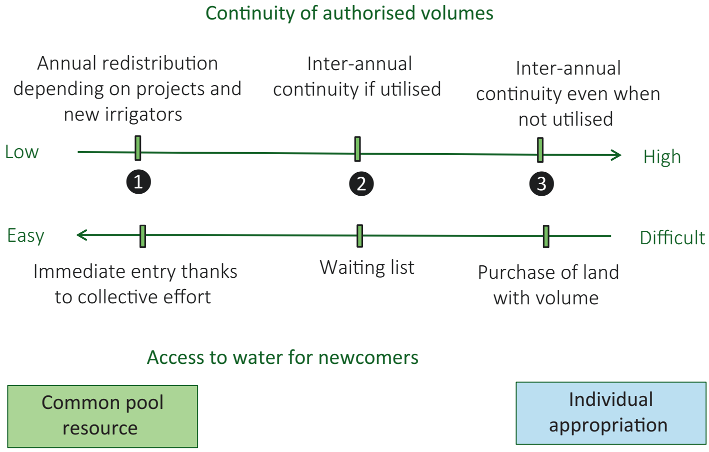


Fig. 3.4 Different approaches for choosing the beneficiaries that can use the volume allocated

The following three examples demonstrate how beneficiaries are identified (Fig. 3.4). In some OUGCs, represented by case ❶ in the figure, stakeholders consider that the water resource is a common good to which every farmer should have access to if he needs it. Therefore, it cannot be subject to individual appropriation or even tacit entitlements. The number of farmers that share the authorised volume is likely to vary each year. Consequently, the volume allocated to each farmer varies because everyone has to limit their share in order to meet the demands of new users. The advantage of this system is that it allows young farmers to establish a new farming enterprise and enables farm strategies to be adjusted to market fluctuations. The disadvantage is that it generates uncertainty in terms of the volume that each farmer can expect to obtain, which is incompatible with perennial crop production or new investment in irrigated crop production. This flexible approach is currently applied in the Aisne county where farmers are very reactive to market changes and water still relatively abundant.[7]

Case ❸ represents a situation that is diametrically opposite, and in which the volumes attributed to each individual are automatically renewed each year, regardless of whether or not the volume has actually been used. The underlying logic is that rights are acquired on the basis of previous use. The volume attributed to the farmer actually becomes tied to the land, thereby increasing its value. A newcomer who wants access to a volume of water must buy land with an individual volume attached, at a price that is two or three times higher than for the same land without a water entitlement. In this type of situation, water is implicitly privatised. This management method provides considerable security to the holders of a historic water right, which means they can optimise their investments (equipment, planting). Its main disadvantage is that it makes it harder for young farmers to establish new

[7] A reader not familiar with the French context should keep in mind that rainfed agriculture is possible over the entire French territory. An interannual variation of water allocation therefore does not systematically threaten the economic viability of farms.

irrigation (due to the cost of accessing water), and does not necessarily encourage efficient water use. In fact, the volume allocated to a farm based on historical use may be completely different to irrigation practices 10 years later. In an extreme case, significant unused volumes of water are needlessly frozen and cannot be reallocated to and used by other farmers. This approach to groundwater management currently applies in the county of Tarn-et-Garonne.

Example ❷ represents an intermediate approach. The volumes attributed are automatically renewed within the limits of the volume abstracted the previous year. Thus a farmer whose usage does not reach the full allowance that was requested in 1 year, will see his allowance decrease to the same volume of usage in the following year.[8] The advantage of this management method is that it allows dormant volumes to be reallocated to newcomers on the waiting list, while guaranteeing a degree of continuity in terms of the volume allocated to users. However, it fails to encourage farmers to improve the efficiency of their irrigation practices because, if they save water, their volume is likely to be reduced. This type of situation can be found in the Clain Basin in the county of Vienne.

The criteria chosen to determine the volume attributed to each beneficiary also vary from one OUGC to another. Diagrammatically, the existing approaches can be spread along an axis with two opposite poles: distribution based on an analysis of the agronomic requirements on one pole and distribution based on the farm's historic activity on the other. The first approach (on the left of Fig. 3.5) involves distributing the volume in relation to the beneficiaries' real needs. Water is allocated proportionally to the theoretical requirements of the crops they plan to grow. The agronomic calculation of water requirements may account for the soil characteristics, which means that the volume per hectare can be increased for soils with a low water holding capacity, for example (case ❶). The allocation rule is seen as a tool that compensates for natural inequalities and provides a level playing field for beneficiaries. It should be noted that the calculation is based on the assumption that

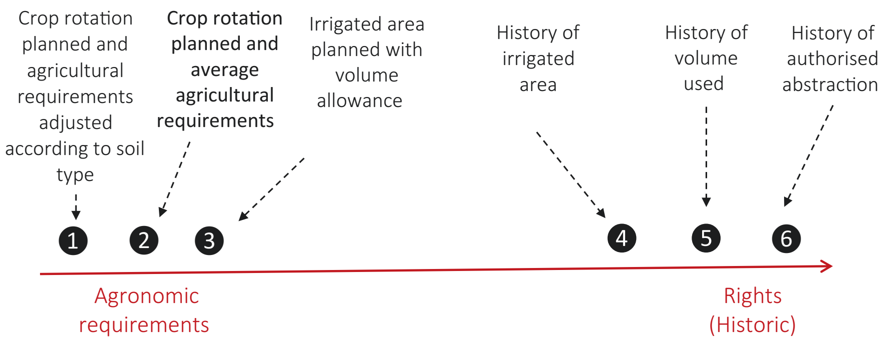


Fig. 3.5 Criteria for allocating the volume to beneficiaries

[8] This rationale is also applied in the western U.S. where the holder of a water right must use it ("beneficial use") to avoid losing it ("*use it or lose it*"). Hanak & Stryjewski, 2012).

irrigation practices are efficient, and therefore it penalises inefficient farmers and encourages water saving. A simplified version of this approach does not take account of soil differences and bases the calculation for distribution on the average agronomic water requirements per crop type (case ❷). A further simplification ignores crop differences and allocates water as a function of the number of hectares to be irrigated in the following season (case ❸).

In the second approach (on the right of Fig. 3.5), the volume is distributed on the basis of the irrigation history of each farm. This approach implicitly acknowledges that historical use creates a right. Here, the primary method used involves allocating volumes as a function of the area of land irrigated historically, irrespective of the types of crops (case ❹). The volume can also be allocated on the basis of former water abstraction (case ❺). Lastly, the volume allocated may be proportional to the volume or the authorised abstraction at the time when the well or borehole was installed, regardless of the actual volume of water used more recently (case ❻). These variations can be found in the various management policies implemented in different French OUGCs (Figs. 3.5).

The previous paragraphs and figures illustrate the range of the strategies adopted by French stakeholders to share the maximum volume that can be abstracted in overdeveloped catchments. The diverse range of approaches is in response to the large variation in the hydrogeological and agricultural situations, the level of pressure on the resource, and also the history of water management in each catchment. Thus when individual volumes have been allocated to users for several years with automatic annual renewal, the notion of rights becomes established in people's minds, leading to the individual (albeit implicit) appropriation of water. In these catchment areas, farmers are likely to perceive any reduction in their volume as an expropriation. The situation is very different in catchments where volumetric management is a fairly recent phenomenon and where demand on resource access is moderate. A wide range of scenarios can be considered in these areas, which gives the OUGCs a broad scope for developing a set of rules for distribution that is acceptable to the vast majority of users.

3.6 Discussion

3.6.1 Refusing Individual Appropriation

By describing the changes in the water management policy and its practical application, this chapter has revealed the permanent tension that exists between private property and the common heritage. This tension is reflected by several contradictions between the theoretical approach as set out by law, and its practical application.

The first contradiction is of a legal nature. According to the Civil Code, groundwater is still considered as a private resource linked to the land. Yet in practice, the regulations established between 1935 and the present day have systematically sought to reduce the exercise of this property right to protect the public interest. In the 1992 and 2006 Acts, water was attributed the status of a common heritage of the nation, without revoking the article in the Civil Code.

The second contradiction is linked to the status of the abstraction permits granted by the State. The permits have been temporary and annually renewable since 1992 and, theoretically, can be reduced without compensation. Yet when the permits had to be reduced in overdeveloped catchments, the State indirectly (partially) compensated for the losses incurred by the users by subsidising the provision of alternative water resources. This primarily involved the development of small dams capable of storing excess winter surface water, or groundwater pumped from the aquifer when it "overflows" in winter. The water agencies subsidised investments by up to 40–70%. This funding was granted subject to three conditions: (1) the irrigated area should not increase; (2) water savings were made by improving the technical efficiency of irrigation; and (3) a regional development project was drafted, proposing a shift in agriculture towards a less water-dependent model. The Poitevin marshes provide a perfect illustration of this situation, which is discussed in Chap. 18. The notion of regional project development is also discussed in Chap. 24.

The third contradiction is linked to the fact that the abstraction permits are non-transferable (for a more detailed discussion see Hérivaux et al., 2019. In the late 1990s, the allocation of individual quotas and the increasing scarcity of water created the necessary conditions for the emergence of a water market by the end of the 2000s. However, national legislators systematically refused to formalise it. This resulted in a land-based water market, in which water abstraction permits were transferred when land changed hands and the price of the land reflected the value of the associated abstraction permits. The desire to avoid using a market mechanism for groundwater users was clearly stated in the 2006 Water Act, which promoted collective management for the volumes to be abstracted, at least in the agricultural sector. Collective management represented a mechanism with the potential to introduce flexibility into resource allocation. Equity remained a goal, but efficiency was sidelined. Therefore, there was a clear move towards negotiated and subsidiary policies, based on the strengthening of the role of the user communities.

The tension between appropriation of water-use rights and defending the public good has now eased with the establishment of collective water resource management mechanisms, based on the creation of intermediary institutions and the notion of common property.

3.7 Future Challenges

For years, groundwater was invisible and regarded as abundant, cheap and freely available. Now, it is a resource that must be shared amongst competing users, including the environment. In France, this situation has sparked conflicts that are likely to worsen in the future, especially when the impacts of climate change become apparent. Rising temperatures and increased evapotranspiration will lead to an increase in water requirements, especially for agriculture. Aquifer storage volumes could also diminish as abstraction increases to replenish surface water. The frequency of droughts will increase in the north and south of the country, even though the northern zone may also have higher winter rainfall. Research projections suggest that a decrease of 10–25% in recharge is to be expected. Two zones, the Loire Basin and south-west France, will be more severely affected (see Chap. 2).

To deal with these future challenges, there is a consensus among French stakeholders on the need to adapt by striving to optimise consumption in all sectors, improving the management of the available resources and seizing all opportunities offered by technological progress. The simplest, most immediate and least expensive response is to avoid wastage of water, particularly by reducing leaks in the drinking water distribution system and raising consumer awareness about how to save water. The example of the Gironde aquifer (presented in Chap. 12), illustrates the enormous potential of this preliminary adaptation. Agriculture must also change to become less water dependent and therefore, less vulnerable to the risk of drought. In France, alternative strategies based on agroecology and agroforestry have attracted particular interest. Varietal selection of plants with drought resistance is one such approach. Reorienting some sectors is probably inevitable, for example, substituting sunflower crops with maize which has a lower water use. However, this strategy has limitations. Sorghum will not replace high value-added fruit and vegetable crops which have a higher water use but create greater employment in the production chain.

A second option for adaptation involves managing the state of the catchment surfaces. Drainage netwoks, the sealing of open spaces (e.g. car parks) and hedge removal have accelerated water runoff and reduced infiltration into the soil and aquifers. Regional development should be reviewed so that water is held and infiltrates where it falls. Aquifers can be used as natural reservoirs, which could be artificially recharged when surface water is abundant. When these aquifers are full, excess water can be stored in surface reservoirs. The State is actively encouraging this course of action, but the limitations are also being examined. To what extent can groundwater extractions in winter be used to fill surface reservoirs without impacting on the groundwater resources available in the following summer?

Finally, the pressure on groundwater resources could always be eased by the development of seawater desalination plants. As yet, there are none on French soil, which suggests that the crises experienced in Australia and western U.S. states are still only a remote prospect for France.

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