Sectoral versus environmental scales: implementing river continuity restoration and river basin approach in areas of production

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Highlights

- This article studies problems of scale when implementing the river continuity restoration and the river basin approach within the EU Water Framework Directive (WFD).
- It focuses on implementation in areas of production linked to hydropower and irrigated agriculture in southwestern France.
- “Sectoral scales” are understood as scalar issues linked to the economic and political practices of industries.
- Grasping how sectoral scales cross with ecological ones is critical for better understanding social and ecological interdependencies at stake and key obstacles implementing the WFD in areas of production.

In the context of Water Framework Directive (WFD) and the objective of "good ecological status" of European water bodies, both the idea of river continuity restoration and the river basin approach call for a scalar transformation of water governance based on ecological principles. Among the WFD literature, very few have focused on industrial actors in areas of production and their role implementing or countering these principles. To observe this, it is argued that one must first grasp the sectoral scales linked to economic actors’ practices. We define sectoral scales as the scalar issues related to industries practices and then question how they have been challenged by new environmental scalar configurations. Using case study analysis, this article focus on two industries in southwestern France in the Adour-Garonne hydrographic District, namely hydropower and irrigated agriculture. The results highlight that implementing river continuity restoration and river basin approach challenge the economic and political practices of these industries related to the spatial scope of their production process and their political jurisdiction. In the face of change, industrial actors defend “functional” perimeters for their activities by rescaling water governance in order to keep control over water resources and maintain the institutional arrangements they have forged within those boundaries. In conclusion, we suggest that research on changes of scales relating to water governance should further question economic actors and how their practices are ultimately entangled in specific scales. Only in so doing can we understand deep-rooted obstacles to the implementation of the WFD in areas of production and better grasp social and ecological interdependencies at stake.

Key words: Scales, river continuity, river basin approach, water governance, European water framework Directive, industries

1. Introduction

Within the European Union (EU) Water Framework Directive (WFD), scalar issues are seen as a means of ensuring the sustainability of aquatic ecosystem and achieving the objective of "good ecological status" (GES) of European water bodies[1]. Two measures notably bring into play the scales of water governance. First, the WFD requires Member States to govern their water bodies at river basin scales by producing River Basin Management Plans. Designed for decision-makers to define and evaluate their water policy choices, these basins perimeters cut across pre-existing jurisdictional/administrative boundaries. Second, the WFD promotes river continuity restoration as good practice to achieve GES objectives by restoring fish migration and natural sediment transport at the watershed scale previously fragmented by hydraulic infrastructures linked to socio-economic activities.

Both river basin approaches and river continuity restoration policy call for new environmental scalar configurations, thereby potentially challenging pre-existing jurisdictional and socio-economic boundaries (Cleaver and Franks, 2005; Drouineau et al., 2018). The literature has pointed out the problems of scale articulations in water governance issues and conflicts across competing scales (Moss and Newig, 2010). In this regard, water governance is understood by scholars as a complex process due to the multiplicity of actor's networks, institutions and regulatory arrangements (Cleaver and Franks, 2005). To better understand the problems of scale, we believe one must first seek to understand what these scales are exactly, how actors and institutions are embedded in them and why they might conflict with each other. That being said, if the literature generally considers water governance to be scale-sensitive related to institutional misfits between hydrographic and jurisdictional/administrative scales (Moss and Newig, 2010; Cohen, Davidson, 2011; Molle and Mamanpoush, 2012), some authors have pointed out an absence of empirical work on "sectoral scales" linked to socio-economic activities (Özerol and Bressers, 2015).

Studying irrigated agriculture in Turkey, Özerol and Bressers define sectoral scales both as the jurisdictional scale referred to the administrative system of irrigated agriculture in space and the agro-ecological scale which favours production related to interdependencies between environmental and agricultural production systems (Özerol and Bressers, 2015). In a completely different research field of political economy, Bernard Jullien and Andy Smith define scales linked to industries activities as jurisdictions, spaces of economic calculations of firms' strategies and finally spaces of legitimation (Jullien and Smith, 2012). Drawing on these insights, we approach "sectoral scales", as the spatial dimension of the economic and political practices of industries:

- the spatial scope of production processes including industrial organization in space, its control over water resources and the hydrographic territory they have shaped.
- the political jurisdiction including the perimeters within which industrial water uses are regulated by sectoral public policies and the spaces of professional representation, legitimation and political alliance.

Understanding "sectoral scale" is important because in certain territories, industries such as hydropower and irrigated agriculture are key actors in water management. Water resources constitute a major production condition in both industries' respective political economy and the grey literature commonly identifies them as the main users of continental aquatic

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060

environments in terms of both water withdrawal and consumption and impacts on river continuity through the building of dams and irrigation reservoirs. With the implementation of the WFD, new environmental scalar configurations linked to river basin approaches and river continuity restoration policy are generally not relevant for hydroelectric and irrigated agricultural issues. Industrial actors then tend to defend sectoral scales because they are functional in terms of production and politics. That is why I argue that the scalar conflicts in areas of production can represent a challenge for the implementation of the Directive but also that the expected scale changes can be shaped by pre-existing sectoral scales.

In river basin studies, although economic actors are not absent from analyses, they are more often treated more as an element of context than an object of study *per se*. If studies on scales of the hydropower industry are less common, several studies have highlighted the spatial scale mismatch of agriculture confronted with the river basin approach (Ferreyra and al., 2008; Pelosi and al., 2010; Özerol and Bressers, 2015). For its part, river continuity restoration as a recommendation has been somewhat overlooked in the WFD literature. This article seeks to help fill these knowledge gaps by drawing on two cases studies related to the implementation of the river basin approach and river continuity restoration policy in hydropower and irrigated agriculture production areas in southwestern France. Three interwined objectives will guide us in questioning the role of industrial actors on the implementation of these principles and ultimately in better understanding problems of scales in areas of production:

i) Define the sectoral scales linked to hydropower and irrigated agriculture through the spatial dimension of their economic and political practices.

ii) Explain why and how new environmental scalar configurations linked to river basin approach and river continuity restoration policy challenge and redefine sectoral scales.

iii) Demonstrate how knowledge on sectoral scales can shed light on social and ecological interdependencies at stake and deep-seated obstacles to the implementation of WFD in areas of production.

The first objective combines multidisciplinary research on the scales of water governance with political science analysis of scale applied to industries to grasp the scalar issues governing hydropower and irrigated agriculture. The second and the third objectives provide empirical elements and reflections on the implementation of the WFD and underlying changes of scale in areas of production. The article is organised as follows: Section 2 presents the European and French political framework of the river basin approach and the river continuity restoration policy and how they fit into the academic debates on scale issues. Using case study analysis, section 3 presents the results related to hydropower and irrigated agriculture industries in southwestern France. In the conclusion, drawing on the case studies, I summarize results and discuss European WFD implementation challenges in areas of production.

2. The case of river basin approach and river continuity restoration policy

Although river basin approach and river continuity restoration principles are distinct in the WFD: the former refers to the establishment of new regulatory perimeters and boundaries for public action related to water governance, and the latter to a good practice for the development of watercourses and their physical restorations, both aim to better take into account the natural scales of water. As such, they challenge the jurisdictional and socio-economic scales. In this section, I present the scientific debates on scales of water governance in the light of these two principles and how they are framed in the WFD and implemented in France.

2.1 Scientific debates on scales of water governance

The river basin literature is generally divided into two epistemological postures: functionalist and constructivist. For functionalist approaches, water problems can be sustainably governed using "natural" scales (Ekstrom and Young, 2009): in other words, the water governance perimeters should naturally correspond to the physical territories covered by the water body. These authors highlight the "functional misfit" between the governance scale designed by administrative, socioeconomic and political activities, and those of ecosystems. For their part, constructivist studies hold that functionalist approaches to water issues are political first (Guerrin et al., 2014). Unlike the multilevel approach, the notion of scale from this perspective assumes that they are neither given nor hierarchized *a priori* but are socially constructed according to actors' scalar practices, i.e. when they seek to legitimize certain scales of public action over others as jurisdictions to govern water problems (Delaney and Leitner, 1997; Marston, 2000; Jullien and Smith, 2012). On this basis, it can be said that the scales supported by stakeholders are directly linked to the relationships, networks, and natural flows that benefit those same stakeholders. All of the studies questioning a functionalist approach agree on a central point: water issues involve multiple actors and public policies, stretching far beyond the confines of river basin boundaries. This has been defined by Cohen and Davidson as an asymmetry between watersheds and "problem-sheds" and between watersheds and "policy-sheds" (Cohen, Davidson, 2011). Indeed, very often in practice, the river basin unit is not relevant when dealing with sectoral issues and established public action networks, as shown by Ferreyra and al. (2008) in the case of water quality protection in the farming industry. In that sense, an approach to water governance which only focuses on supposed natural territoriality can lead to political, socio-economic and even cultural scales being overlooked (Moss, 2012).

In comparison, the question of scales related to river continuity restoration has remained largely absent from the WFD literature. Previous works have mainly focused on social acceptability issues related to physical restoration of water bodies' when they involve riparians and watermill owners defending their representation of water landscapes and their attachment to the fluvial cultural heritage (Fox and al., 2016; Barraud and Germaine, 2017; Perrin, 2018). Yet, there is a strong but implicit scalar dimension in the river continuity principle due to the prospect of physically reconnecting upstream and downstream of a watershed understood as ecologically interdependent. Such projects involve the composition of a new environmental hydrographic territory historically fragmented by physical obstacles related to socioeconomic uses of water. Therefore, while the changes of scale linked to the river basin approach are administrative and jurisdictional (governing water at the "right" scales), river continuity restoration can challenges the spatial scope of industries' production processes, i.e. industrial organization in space, its control over water resources and the hydrographic territory they have shaped.

2.2 The European framework

With the objective of achieving the "good ecological status"' of European water bodies, the WFD requires first that Member States "identify the individual river basins lying within their national territory and […] assign them to individual river basin districts" (Article 3). These river basin units are designed to be a functional ecosystem scale for reviewing the environmental impact of human activity and the economic analysis of water use (Article 5). Finally, by committing the Member States to produce a River Basin Management Plan for each river basin district (Article 13), these hydrographic units also refer to regulatory

perimeters and governance bodies delimiting frontiers for public action. However, there is no obligation for Member States to create dedicated government bodies competing with traditional jurisdictions to manage these hydrographic territories. Instead, as a result of pressure from certain countries with a federal system of government, Member States have a certain amount of flexibility in the way they organise their governance and appropriate competent authority (Moss, 2012). As a result, the way of governing these districts also depends on national configurations prior to the WFD.

Secondly, in order to achieve the "good ecological status" of European water bodies, the WFD mentions river continuity restoration as good practice (annex 5) for hydro morphological and biological improvements (especially migratory fish)[2]. Conversely to the river basin approach, river continuity is absent from the main text of the WFD. It does not constitute an obligation, but a recommendation addressed to Member States based on the identification of ecological water quality factors. Nevertheless, the need to restore river continuity is regularly highlighted by the European Commission in its reports on the implementation of the WFD and its recommendations to Member States[3]. In this context, some countries including France have developed an ambitious river continuity policy around this concept.

2.3 The French interpretation

In French water policy, neither the river basin approach nor river continuity restoration were new ideas, but the WFD has been used as a resource for strengthening their national implementation. In terms of river basin approach, the first water law of 1964 laid down the principle of water governance at the river basin scale by dividing French metropolitan territory into six watershed agencies. Such perimeters formed hydrographic networks within which ecological flows were supposed to be interdependent and could therefore be governed in a sustainable way. Into the 1990s, the growing popularity of the concept of *Integrated water management*[4] gave rise to the use of watersheds as the "ideal" governance unit (Molle, 2009). The second water law of 1992, introduced planning instruments and management boards at the river basin and sub-basins scales (which constitute sub-divisions of the river basin districts) bringing together public and private stakeholders. In 2000, the river basin scale as governance units have provided a benchmark for implementing hydrographic districts required by the EU under the WFD. France in particular could then meet the requirements of the WFD with few administrative changes thanks to its basin organizations (Kallis and Butler, 2001). For the first time, ecological water quality objectives were set within the WFD and Member States had to achieve good ecological status of water bodies within the river basin scales (Bouleau, 2008). France continued to decentralize water governance by setting up management boards for the sub-basins to facilitate the implementation of the River Basin Management Plans and, ultimately, to achieve the objectives of the WFD. However, unlike the River Basin Management Plan, their development is not compulsory; they were not created in all territories and especially not in areas of production. The WFD nevertheless had

[2] The good ecological status of European water bodies is determined by criteria of biological quality (presence and quantity of populations of species), physicochemical (oxygen, nitrogen, phosphorus, water temperature, etc.) and hydro -morphological (morphology, sediment transport and hydraulic regime).

[3] See the Assessment of the second River Basin Management Plans in 2019 by the European Commission : https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=SWD:2019:30:FIN&qid=1551267381862&from=EN

[4] *Integrated water management* is a mode of governance that takes into account all the uses related to an aquatic ecosystem in the same hydrographic area referred as a watershed scale to ensure its sustainability.

a positive effect on their implementation and the number of sub-basin management plans has steadily increased since then.[5]

River continuity restoration appeared very early as a public problem in 1865 within the framework of a national law which imposed the installation of fish passes on certain hydraulic infrastructures to re-establish the free movement of migrating fish. Later, in 1919, a law related to the use of watercourses for hydropower introduced river classifications. Two lists of watercourses were then identified by the French authorities: the "reserved watercourses", for which any new hydroelectric structure was prohibited and the "classified watercourses" on which any new structure had to be equipped with a fish passes. However, river ecology was far from being the dominant doctrine at that time and the booming hydropower and irrigated agricultural limited the implementation of the river continuity policy (Barraud, 2011). Despite this, reflections on fish migration and fragmented aquatic landscapes emerged at this time, which laid the foundations for current representations of river continuity policy. In 2000, the WFD put it back on the French political agenda. The Directive gave rise to a third water law in 2006 before being discussed during the Grenelle Environnement Forum which introduced new requirements for river continuity restoration policy (Perrin, 2018). In this context, a national plan to restore river continuity has been drawn up by updating the old classifications of watercourses. This national plan aims to build fish passes, to remove the most problematic obstacles to fish migration and finally to prohibit the construction of new hydraulic infrastructures which would disrupt river continuity. In view of the non-compulsory nature of the river continuity restoration in the WDF, some authors have considered the implementation of this national plan as a form of over-transposition of the Directive (Bravard and Lévêque, 2020).

In France, the WFD has strengthened the implementation of sub-basins and river continuity restoration, whereas they had been slowed down in the past in areas of production related to hydroelectric and agricultural activities. From two cases studies, the following section questions how their current implementations challenge sectoral perimeters and how industrial actors' scalar practices participate in shaping the scales of water governance.

3. Case study: Hydropower and irrigated agriculture scales facing environmental scales in southwestern France

Using case study analysis, the following section focuses on the WFD implementation and the underlying change of scale in hydropower and irrigated agriculture areas in the Adour-Garonne hydrographic district. I focused on two very specific areas of production within this district corresponding to the sectoral scales of these two industries, competing with the ongoing implementation of the sub-basins approach and river continuity restoration: the *Dordogne* valley (hydropower industry) and the *Lot-et-Garonne* County (irrigated agriculture)[6]. The two case studies show areas where strong production issues and the implementation of the WFD confront each other and result in scale conflicts.

The *Dordogne* valley is a low mountain sub-basin located north of the Adour-Garonne district. This *valley* is one of the major hydroelectric production areas in the hydrographic

[5] 68 sub-basin management plans were identified as necessary in the River Basin Management Plans approved in 2009 (plans 2010-2015) to achieve the objectives of good ecological status; and 62 in 2015 (plans 2016- 2021) : https://www.eaufrance.fr/publications/sub-basin-management-plans-20

[6] County as refered as french *Department* which is a subnational administrative and political scale.

district with numerous storage dams upstream and several run-of-the-river dams downstream[7]. 58 dams are currently exploited by *Electricité De France* (EDF)[8] which has been mostly built between the 1930s and 1960s. Paradoxically, the Dordogne valley is also the last watershed in Western Europe to still shelter the majority of migratory fish species historically present on the Atlantic coast; this is how the valley has been classified since 2012 as a world reserve of biosphere by UNESCO with the aim of better regulation to protect these species.

In France, the County scale is a reference unit for elected trade union organizations and sectoral public policies regulating water resources for agriculture. The *Lot-et-Garonne* County that is part of the *Nouvelle-Aquitaine* region which is one of the French regions with the highest water withdrawal rate for irrigation and the highest number of hectares of irrigated plots. In this County, farming activities constitutes the primary sector of the local economy mainly thanks to irrigation. During the 1980s, the number of hectares of irrigated plots doubled to reach about a third of the agricultural territory in the County. One of the particularities of the County is that the development of irrigation has been accompanied by the creation of many hill lakes which still makes it today one of the Counties most equipped in irrigation reservoirs despite controversies over their impacts on river continuity.

Our case study uses multiple sources of data from interviews to grey literature which made it possible to cross-check and clarify our material (Yin, 2009). More than 40 interviews were conducted with private stakeholders (farming representatives, hydroelectric plant manager, representatives in charge of institutional relations), public bodies (decentralized state services, local authorities, Local Public Basin Establishment, water agency), as well as NGOs (nature protection association, recreational fishing association). The findings are also supported by various sources from the grey literature, namely European Commission reports, decentralized state services documents, parliamentary consultations, and industrial publications such as white papers.

For each of these areas of production related to hydropower and irrigated agriculture, we first define their sectoral scales. Second, we examine the attempted implementation of river continuity restoration policy by focusing both on the ecological management of water flows for the protection of migratory fish and the construction of fish passes linked to the hydropower industry and the controversy over irrigation reservoirs. Third, we question the changes of scales linked to the river basin approaches by focusing on the implementation of sub-basin management boards in the *Dordogne* valley and hydrological unit for quantitative water management in the *Lot-et-Garonne* County. In the conclusion, drawing on the case studies, I summarize results and discuss EU WFD implementation challenges in areas of production.

3.1 The hydropower industry in the *Dordogne* valley

3.1.1 The valley, a hydrographic territory shaped by the hydropower industry

As a result of the development of hydroelectric dams during the 20th century, the hydrographic landscape of the *Dordogne* valley has been altered, shaped by creating reservoir lakes which retain water for energy purposes and modify ecological flows. This had negative impacts on river continuity, in particular by fragmenting the upstream valley and the Gironde

[7] "Storage dams" are characterized by a high production capacity and a significant waterfall. Located in mountainous areas, these dams have artificial lakes that store water resources to produce electricity at the chosen time. A second category of "run-of-river dams" are located in the plain on the course of large rivers. Unlike storage dams, run-of-river dams only partially retain the flow of water and electricity is produced in real time.

[8] EDF is the largest industrial group producing electricity in France. They also operate nuclear power plants for which they have a monopoly and other sources of energy.

estuary impacting on migratory fish pathways. Dams in the valley are almost all operated by *Electricité De France* (EDF) and form a chain that works together. Coordination between them as a single set of infrastructures makes it possible to manage water at the valley scale in order to optimize production. Dams operated by EDF within the valley are managed through an organisation referred to as a Hydrological Operations Group (HOG). In turn, each HOG is part of a "Production Unit" (PU)[9], which covers a larger geographical area and is responsible for ensuring the industrial performance of several HOGs. Hydropower is the only industry within EDFs remit that is governed in a decentralised fashion. This is explained by the territorial nature of the water bodies involved and the need to provide for climatic and hydrological contingencies in industrial production processes, such as the management of its water stock and timing of electricity production.

In doing so, the industry is very organized on a valley scale but at the same time other industry actors intervene from a larger perimeter such as the PU. In addition, the storage dams in the valley are mainly managed remotely from a *Hydraulic control centre* (CCH) located in Toulouse, which continuously adjusts electricity production based on the balancing needs of the national and European electricity network. The CCH follows a production program sent daily by *EDF's* market production optimization centre. The market-based production process of the storage dams reveals that central parts of hydroelectric activity stretch far beyond the confines of the valley where the infrastructures are located. This production process generates artificial and abrupt variations in local water flows which can destroy fish habitats and impair fish reproduction. In the *Dordogne* valley, this has been a source of protest from the Local Public Basin Establishment[10] and the local fishing association. When dealing with disquiet related to this phenomenon, EDF local stakeholders often highlight the fact that the HOGs have little power over the operation of the storage dams, in attempts to keep the social peace.

On the other hand, the overall control of the hydropower industry over the valley is regularly politicised, not only as an issue of productivity, but also as a form of "territorial responsibility" (Zanetti, 2018) regarding other water issues within the valley, namely river continuity, flood control, water supply for farming and tourist uses. In recent years, EDF has signed agreements with local stakeholders going beyond the relevant regulations on environmental policies. Such agreements commit EDF to participate in major river restoration projects and to guarantee water flows by using their storage dams[11] on specific parts of rivers where fish migration issues are the most important. While some of their practices lead to river discontinuity (building dams, spatial organization, market-based production process), EDF also contributes to ensuring river continuity for migrating fish within the valley such as by guaranteeing water flows whatever the natural hydrological conditions. Yet, for EDF, ensuring river continuity and territorial responsibilities by releasing water is only possible thanks to the overall control they have over the water flow at the valley scale.

3.1.2 Restoring river continuity: Challenging the control and command centres operation and the anthropization of the valley

[9] EDFs hydro-electric power stations in France are divided into 5 *Production Unit* (PUs): PU Alps, PU Centre, PU East, PU Méditerranée, and PU Southwest. Each PU manages multiple HOGs.

[10] The Local Public Basin Establishment intervenes for the development and management of large rivers within the boundaries of the watershed. Its funding is provided by the member counties which cooperate beyond their jurisdictions through this local public basin establishment.

[11] "Guaranted water flow" is more stringent than "minimum water flows". By guarantying water flow, EDF releases water into streams to ensure a specific flow whatever the incoming natural water flows. In the case of the minimum water flow, EDF is under no obligation to use the water it stores if upstream natural flows drop below minimum requirements.

In France, the river continuity restoration has been a policy window seized by recreational fishing associations and local elected officials to dismantle hydroelectric dams, mainly on the *Sélune* river whose waters flow into the bay of Mont-Saint-Michel (Germaine and Lespez, 2014). But such cases are still exceptional in France and depend on a strong local politicization of river ecological issues. Until now restoring river continuity in the *Dordogne* valley for EDF has most often involved the construction of fish passes and the adaptation of production processes for migrating fish: e.g. reduction of artificial and sudden variations in water flows and adaptation of the production schedule to the fish migration season. Such measures related to production processes limit the right to operate dams as economically desired by the industry's control and command centres; they de-optimize the production of electricity and constrain the management of their water stock by taking local ecological data into account in their forecasts. Although hydropower generation rules of storage dams are still mainly centralized and defined by a nationwide and European optimization logic, they are increasingly adapted to the ecological issues of local watercourses. Dealing with river continuity, the HOG is prompted by other local stakeholders to be more autonomous vis-à-vis the PU and the CCH in the management of its production processes.

In terms of fish passes, the anthropization of the valley has played an important role in the selection of public policy instruments. EDF stakeholders indeed highlight the technical limits to build fish passes for upstream dams (mainly storage dams) and defend energy issues attached to this part of the valley. The measures aimed at restoring fish-migration therefore have led EDF to carry out civil engineering on their downstream dams, which are the first obstacles to fish migration. But, the actions envisaged were framed by the anthropization of the upstream part of the valley which was mostly spared by such measures. First, because experts currently consider that fish cannot successively pass several dams although they are equipped with fish pass. For this reason, the costs for EDF to restore river continuity by building fish passes were considered disproportionately high. Second, because the upstream part was mainly reclassified as "Highly Modified Water Bodies" (HMWBs) due to its significant anthropization[12]. This European classification introduced by the WFD makes it possible to integrate into the political decision the degree of physical alterations of the aquatic environment linked to human activities, which, "for technical or economic reasons", cannot be restored to a good ecological status[13]. Finally, local stakeholders generally assume that the upstream valley is mainly dedicated to electricity production, which, in some ways, spares this part of the valley from too restrictive measures.

3.1.3 Implementing sub-basin management boards: Challenging the Hydrographic and stakeholder networks shaped by the industry

The creation of the Local Public Basin Establishment in 1991 from an agreement between several Counties crossing the *Dordogne* valley circumventing the implementation of sub-basin management boards introduced at that time by central Government (Vieillard-Coffre, 2001). In this context, for years, discussions about ecological issues linked to EDF's activity mainly took place through contractual arrangements including a small number of stakeholders

[12] HMWBs are listed in the frame of the River Basin Management Plans bringing together public and private stakeholders and are reviewed every six years at each cycle of the River Basin Management Plans.

[13] Within the Adour-Garonne district, hydro-electricity activities were one of the main reasons why rivers and lakes were classed as Highly Modified Water Bodies. See the European Commission working document of 26.2.2019 on the second River Basin Management Plans of France: https://ec.europa.eu/environment/water/water-framework/pdf/Translations%20RBMPs/France.pdf

as the Local Public Basin Establishment, the water agency[14], the de-centralised government bodies, EDF, and the local Fishing Association. But in recent years, as part of the WFD implementation, the water governance in the valley is being divided into four sub-basin management boards: each include new private and public stakeholders, specifies water quality objectives, sets out priorities for action and has legal force by institutionalising rules of water use in compliance with the framework established by the River Basin Management Plan. The institutionalization of these new governance perimeters redefines the hydrographic boundaries of the area, so that the valley scale as a single unit used by the industry should be no longer relevant for water governance. The implementation of these new perimeters not only called into question the hydrographic network shaped by the industry for production, but more specifically, the relationships it has forged within these boundaries.

With hydropower infrastructure spread across three of these four sub-basins perimeters, EDF is now called upon to manage the dams it operates taking into account these new local jurisdictions. Before that, EDF used to work politically at the valley scale. Especially since the renewal of several hydroelectric concessions in the valley in the early 2000s, followed by the ongoing EU liberalisation opening concessions to competition, EDF has attempted to prove its territorial responsibility and forge political alliances. Since then, EDF has created a department to manage environmental issues and satisfy other water uses within the valley. The firm has also redistributed across the valley scale part of the profits from the hydroelectric activity by investing in multiple projects, in particular by supporting small local businesses in the electricity sector and local tourism. By doing this, EDF has built a stakeholders' network, strengthening its political power within the valley boundaries to enhance its legitimacy and deal with production problems linked to water management. As argued by Gaudin, environmental flows can also reveal flows of economic capital as part of governing the water resource (Gaudin 2017). In that sense, we can say that the hydrographic network shaped by EDF is not only made up of water flows but must also be seen as a stakeholder network, home to both socio-economic and political flows. It is especially these which are challenged by reshaping the valley in distinct sub-basin areas.

3.2. The irrigated agriculture in the *Lot-et-Garonne* County

3.2.1 County as a political scale for the industry

The County is traditionally the scale at which agricultural water uses are regulated by sectoral public policies, but also the scale from which agricultural organizations derive their political power both from union elections and alliances with local public actors. The development of irrigated agriculture in the County is first of all the result of a policy pursued by the County Council in the 1970s for promoting the construction of irrigation reservoirs. Even with the controversy over the ecological impacts of these irrigation reservoirs, the local elected representatives keep promoting irrigation development. When dealing with production problems linked to water management, the industry very often turns to county representatives to make compromises that actors at other scales of public action will not make. In addition, agricultural water management is under the regulatory control of decentralised state services also working at the County scale. These deal with agricultural projects that require authorizations (e.g. construction of irrigation reservoirs, etc.) and the monitoring of agricultural water withdrawals. In the Lot-et-Garonne, decentralised State services have had difficulty freeing themselves from their local political environment and especially pressure

[14] Water agencies are public administrative establishments with financial autonomy thanks to the fees they collect from users. They contribute to water policy within the boundaries of watersheds, in particular by redistributing financial aid for the sustainable management of water.

exerted on them by agricultural unions, also organized at the County scale. Of course, the political power of decentralised State services stems from their autonomy to arbitrate the demands of the central State in relation to those of local stakeholders (Grémion, 1970). In this regard and thanks to the political context at County scale, local water regulation has developed in favour of the farming industry and its competitiveness. So, the County scale remains an important political resource for forging political alliances, despite being increasingly challenged in its governance of agricultural water uses.

3.2.2 Building irrigation reservoirs despite the controversy

In the slightly hilly landscapes of the *Lot-et-Garonne* County, irrigation reservoirs are built at the bottom of dales across small rivers which are used to fill these hill lakes. In southwest France, summer droughts are a regular occurrence. Under these hydrological conditions, storing water constitutes a means of securing farming production, guaranteeing its quality and yields. For some crops under production contracts, access to water guarantees commercial outlets. Generally, it encourages the installation of new farmers and the conversion of unprofitable farms with more profitable irrigated crops. Yet, within the WFD, river continuity restoration policy has called into question water storage practices by prohibiting the construction of new irrigation reservoirs which would impair river continuity. Nonetheless, and although the creation of irrigation reservoirs has largely declined even in the County, political support enjoyed locally by the farming industry has enabled it to construct hill lakes despite the controversy at national and regional scales.

In 2010, local nut producer associations signed a charter for building hill lakes for their booming sector. This charter involved the County council, which undertook to financially support these projects, and the decentralized State services committed to reduce the time taken to examine project proposals. A second charter was signed with the *Chamber of agriculture* managed by union representatives[15], thus extending the support of local authorities to all irrigation activities. More recently, an old project to build a large hill lake near the town of Caussade was carried out by the *Chamber of Agriculture*. Locally, the project enjoyed fairly broad social acceptability until other scales of government intervened. After having been discussed at the County scale for several years, the project was finally authorized by the decentralised State services at the end of 2018. Facing this authorization, regional NGOs called on the central government to intervene and sued the *Chamber of Agriculture* stressing that the project did not respect ecological standards in particular with regard to the river continuity regulation. A few days later, the controversy grew and the central government ordered the annulment of the authorization given by its decentralized services. This incident ended with the County prefect being replaced. But the local solidarity inspired among farmers by the *Chamber of Agriculture* has proved powerful in terms of collective protest. Farming stakeholders under the lead of the *Chamber* and with the political support of several County representatives opposed the persistent refusal of the central government and the bans handed down by the courts. In a show of force, the *Chamber* organised groups of farmers to avoid being seized of construction equipment and to complete the reservoir construction on their own. After long months of conflict and while the construction of the reservoir in question had meanwhile been completed without anyone being able to stop it, the central government finally let the *Chamber* use the hill lake, but this did not prevent the courts from heavily condemning the union representatives of the *Chamber of Agriculture* some months later. While the construction of irrigation reservoirs is a controversial subject nationally and regionally due to biodiversity and river continuity policies, they are seen at the County scale

[15] The *Chambers of agriculture* are governed by agricultural unions elected by the County farmers. Once elected, a union takes the head of the *Chamber* and benefits from the status of public body.

as economic tools and equipment for rural development. Because of this, *Lot-et-Garonne* is still the County which has one of the largest numbers of irrigation reservoirs anywhere in France and where local authorities still support their creation.

3.2.3 County Scale challenged by the institutionalization of new hydrological units for quantitative water management for agriculture

For a long time, the water use rights for agricultural purposes were administered at the County scale. This corresponds both to the jurisdictions of the *Chamber of Agriculture*, responsible for administering farmers' requests, and to those of the decentralized State services in charge of monitoring. When the WFD arrived, France's third water law in 2006 brought quantitative water management back onto the political agenda as part of achieving good ecological statues. In this framework, a reform which the farming industry strongly opposed established a series of measures directed at achieving balanced water consumption in the southwest of France.

The reform introduced a new set of rules governing how rights to water were given out, based on the volumes available at the scale of hydrological units. The quantitative management of agricultural water would no longer be done within the Counties boundaries but according to ecological perimeters from which the quantity of abstracted water would be defined. The sharing of water would therefore be done according to these new spatial references which created new interdependencies between farmers, no longer by their belonging to a County and automatically to the corresponding *Chamber of Agriculture*, but to a very specific hydrological territory. However the administration of these new hydrological territories has most often been handed to *Chambers of Agriculture*. The *Lot-et-Garonne* County was divided into 3 hydrological units which crossed the boundaries of more than one County. The *Lot-et-Garonne Chamber of Agriculture* was only given responsibility for one of these, with the remaining two placed under the remit of the *Lot* and *Gers Chambers of Agriculture* respectively. This meant that the *Lot-et-Garonne Chamber* lost control of a portion of the farmers for which it had erstwhile been responsible for administering their water requests, with that responsibility passing instead to competing union in neighbouring Counties. As a result, the Lot-et-Garonne chamber no longer controls the totality of water management in the County leading to a decoupling between its traditional political territory and the newly produced water ones.

It is still too early to know if this change could eventually affect union dynamics in the County and weaken the local political power of the *Lot-et-Garonne* chamber. However, the chamber did everything possible to avoid this. First, by contesting the outline of these new perimeters through proposing to collect an operating fee for these new responsibilities at the county scale instead of their given hydrological unit. In doing so, the *Chamber's* objective was to set up a single tax for all the farmers it used to administer to maintain quantitative water management within the County boundaries. However, a ministerial decree quickly put an end to their challenge. Although the *Lot-et-Garonne Chamber of Agriculture* finally accepted the new perimeters, this did not prevent them from subverting their effects and trying to bring union issues back to the management of the hydrological unit. For instance, compared to others, the *Lot-et-Garonne Chamber* has chosen to guarantee water access to all farmers within its remit, and not to charge them the relevant fees. The *Chamber* therefore deliberately invested very little human capital into its responsibility for supervising quantitative water management. In practice, no investigations were carried out before renewing annual water authorisations, and meter readings were no longer taken following periods of irrigation. By failing to provide this data for the decentralised State services, the

Chamber was interfering with the aims of the reform, namely a more rational approach to water management.

4. Conclusions

The first objective of the article was to grasp the scales of the hydroelectric and irrigated agriculture industries. Combining insights from the literature on water governance and industries in political science, we have defined sectoral scales as the spatial scope of their production process (i.e. industrial organization in space, its control over water resources and the hydrographic territory they have shaped) and their political jurisdiction (i.e. the perimeters within which industrial water uses are regulated by sectoral public policies and the spaces of professional representation, legitimation and political alliance). In view of our results, both are very interdependent because the stakes for industries are to keep control over water within the perimeters of their production process to maintain their political jurisdiction and vice versa. From our case studies, hydropower industry is very organized at the valley scale by operating coordinated dams and controlling water flow partly within those boundaries. For its part, the farming industry derives much of its political power from the county scale because it is the first professional representation space for the industry and a scale where they easily forge alliances around rural development policies. For both industries, sectoral scales represent not only optimal production spaces but also political jurisdictions where they find political support and establish institutional arrangements related to water management that favour their view of efficient production.

Second, the objective of the article was to question how the implementation of the river basin approach and river continuity restoration policy could challenge and redefine sectoral scales. It is very clear that while the changes of scale linked to the river basin approach challenge the industries' political jurisdictions, river continuity restoration challenge the spatial scope of their production processes. In the *Dordogne* valley, implementing river continuity restoration policy has de-optimized electricity production by impelling the valley operator (namely HOG) to be more independent from the industry's control and command centers when driving its production processes so that they better respect local ecological flows. In addition, the implementation of sub-basin management boards has challenged the hydrographic network shaped by the industry for production, but also the political relationships it has forged within it. In the irrigated agriculture case, the County scale is increasingly challenged by regional and national scales related to the controversy over the construction of irrigation reservoirs and by the establishment of hydrological unit for governing quantitative water management. Nevertheless, the results also show that sectoral scales have greatly influenced and shaped the implementation of the WFD in these areas. The valley as a water governance unit for the hydropower industry and the County scale for farming have been highly politicized by industrial stakeholders in the face of changing scale. In the *Dordogne* valley, the implementation of the river continuity restoration policy was carried out according to the industrial layout of the area, being framed by the anthropization of the upstream part of the valley and its usefulness for the daily operation of the industry. In the *Lot-et-Garonne* County, the farming industry has bypassed bans on the construction of irrigation reservoirs despite the controversy over their impact on river continuity thanks to the political support they received from various local stakeholders. Furthermore, facing the institutionalization of new hydrological units as jurisdictions for quantitative water management, the *Chamber of Agriculture* has done everything to try to bring water management back into their traditional jurisdiction at the County scale.

Finally, our analysis informs the implementation of river continuity restoration and river basin approaches in areas of production by understanding industrial actors' scalar practices. In the face of change, we have seen that they defend specific hydrographic territories and by doing so, they have shaped the change of scale underlying the WFD. Scalar problems in areas of production can represent an obstacle to the implementation of the Directive. More research could further analyse sectoral scales to better understand these challenges. Despite the empirical results specific to the French case due to the quasi-monopolistic situation of the main hydropower operator or even the historical anchoring of agriculture at the county scale, our analytical tools to grasp scalar issues governing hydropower and irrigated agriculture could be applied to other national cases studies. Indeed, studying the spatial dimension of the economic and political practices of these industries can help first identify sectoral scales; secondly examine how actors and institutions are embedded in them and finally why these scales might conflict with new environmental scalar configurations. Overall, producing knowledges about sectoral scales could thus inform on which social and ecological interdependencies are at stake in areas of production and contribute to the scientific debate on problems of scale in water governance.

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