Bringing politics back into scenarios for water planning in Europe

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Abstract

The shift from government to governance in European water policies conveys a pluralist conception of stakeholder participation in planning. This article argues that the current Driving forces-Pressures-State-Impact-Response (DPSIR) approach to the planning of natural resource use, developed by the Organisation for Economic Cooperation and Development (OECD) and the European Environmental Agency (EEA) is at odds with a pluralistic conception. The DPSIR approach consists in constructing a single socio-environmental model to address a specific problem in water management, while paying no attention to the existence of conflicts surrounding the definition of the issue at hand, the social, political and spatial delimitation of that issue, and the translation of stakes in terms of quantitative variables. Scenarios produced in this process therefore explore a limited range of policies, i.e. those defining the problem in the same way, as illustrated here with the case of the Garonne River in France. This article presents an alternative method, combining knowledge in social science and natural determinisms to build contrasting socio-hydrological scenarios that do not share the same hypotheses regarding their respective key issues.

Keywords

Scenarios, DPSIR, biopolitics, indicators, political geography, water management planning

Introduction[1]

The shift from government to governance in European water policies (Kaika, 2003) conveys a pluralistic conception of stakeholder participation in water management planning. It acknowledges that the allocation of water resources does not only revolve around hydrological expertise, but involves social and political considerations relating to the issue at hand, priorities, uses, compensations, restrictions, sanctions, etc. It requires that stakeholders who neither share the same values nor interests should have an opportunity to debate future options for the use of water. In this pluralistic perspective, scenarios can serve as strategic tools for discussing environmental water policies and plans of action, provided they do not presume a single definition of the issue.

However, the prevailing approach to scenario building for water management planning in Europe often refers to the "*Driving forces – Pressures – State – Impacts – Responses*" (DPSIR) framework, which implies "the demarcation of a particular system of interest, with

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[1] The authors thank the journal DDT for authorising the publication of this amended translation of an earlier paper published in French: Fernandez, S., Bouleau, G., Treyer, S., 2011. Reconsidérer la prospective de l'eau en Europe dans ses dimensions politiques. Développement durable et territoires [Online], Vol. 2, n°3, December. URL: http://developpementdurable.revues.org/9124".

explicit or implicit boundaries" (Svarstad et al., 2008:117). Kieken (2005) highlighted the limits encountered by foresight studies that, despite claiming to be "integrated", tend in practice to be based on a single model which excludes diverging views on the system in question.

The DPSIR framework, or model, was developed in the 1990s by experts from the Organisation for Economic Cooperation and Development (OECD) and the European Environmental Agency (EEA), (EEA, 1995; EEA, 2003; OECD, 1993; OECD, 2000), drawing on the concept of environmental impact, to account for a range of environmental problems and policies in similar terms. Based on system analysis, this model expands the ballistic metaphor of *impacts* used in environmental law to identify *pressures* and *driving forces* responsible for altering the *state* of the environment and *responses* likely to restore it. The framework was easy to transpose to any environmental issue, and became a common reference for modellers in this area. Meanwhile, the Directorate-General for the environment (DG Environment) of the European Commission specifically targeted water management, a field in which models are widely used, as a strategic policy domain (Aubin and Varone, 2002; Kallis and Nijkamp, 2000). Consequently, the use of the DPSIR framework has become particularly pervasive throughout the European Union (EU) in water resources planning, notably for the purpose of comparing the cost-effectiveness of management options – *responses* in DPSIR language – as required in many EU directives.

This framework relies on a single biophysical model representing the environment. It also presumes that the state of the environment, as represented in the model, is a worrying issue upon which society should act. Other possible concerns on the political agenda are ignored, and politically important links between environmental questions and other dimensions – inequalities, for instance – are generally not mentioned. Historical power relationships surrounding water, referred to in social science as "water politics", that resulted in environmental "pressures" in the first place (Alatout, 2008; Espeland, 1998; Trottier and Slack, 2004) are similarly obscured. Garb *et al.* (2008) therefore argue that biophysical models shape the cognitive landscapes of stakeholders invited to contribute to scenarios in "Story And Simulation" (SAS) exercises (Alcamo, 2001), the most commonly adopted approach in the field of research to develop scenarios with stakeholders, and which is presented in section 1. This article proposes an alternative scenario construction method, taking into account the plurality of concerns within society, and consequently identifying which biophysical models would be best suited to different research purposes.

Our method is broadly situated within the critical realist tradition, which rejects strong relativism and positivism alike. It "suggests important truths about nature, albeit generally on different scales (…) and [admits] that all knowledge is partial and a certain degree of relativism is thus unavoidable" (Proctor, 1998:352). The method was tested on the Garonne River. The Garonne River begins in the Spanish Pyrenees and flows 525 km through southwest France down to the Atlantic Ocean, via the Gironde estuary (see Figure 1).

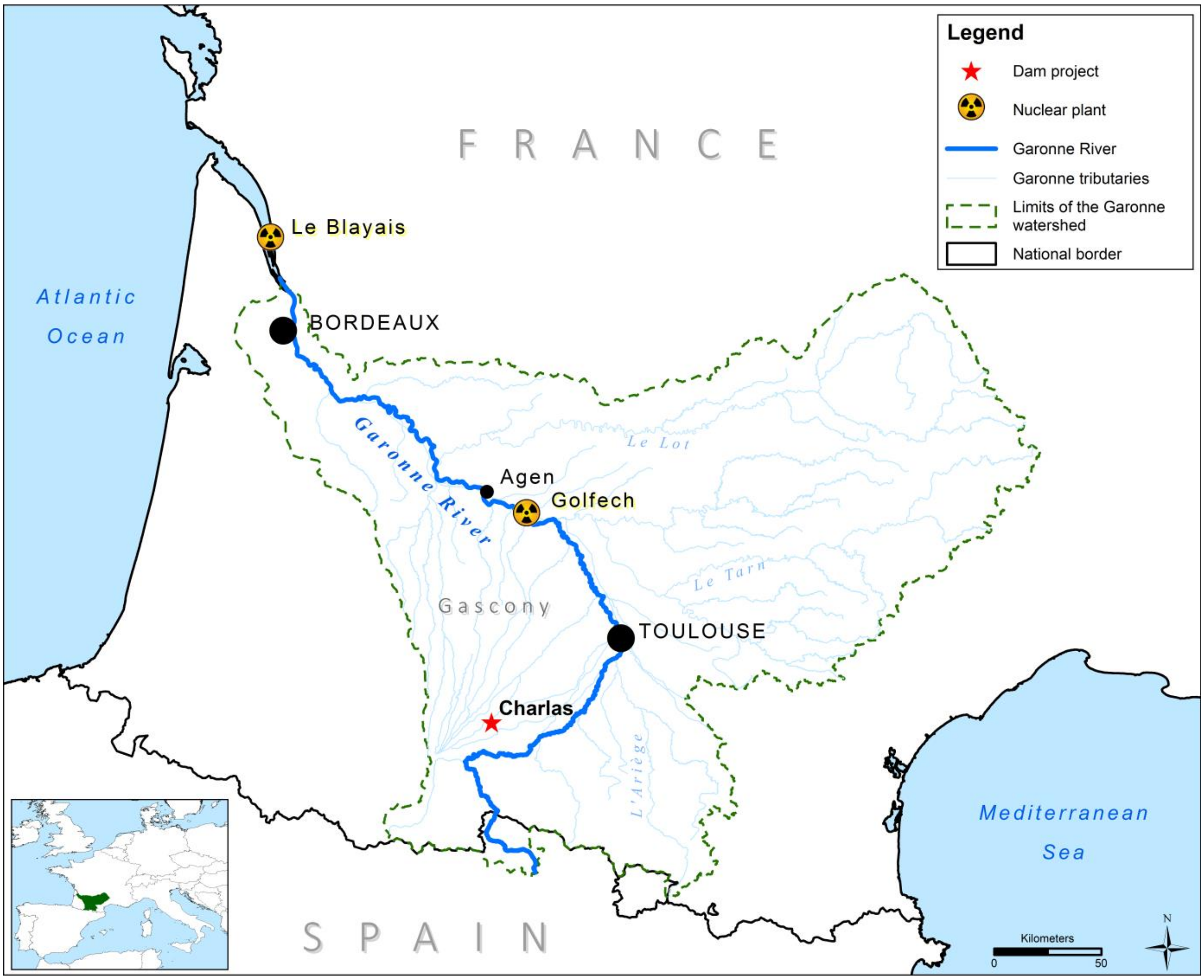

Figure 1: The Garonne River and its main tributaries (Decherf, 2013).

The paper is organised as follows. Section 1 presents the method. It first examines the DPSIR model, discussing its strengths and weaknesses (section 1.1). How social theory can support a society-centred approach is then discussed in section 1.2. From this, we develop a method to build DPSIR models corresponding to different water-related environmental issues (section 1.3). Section 2 deals with the case of the Garonne River, for which a specific socio-hydrological DPSIR-like model was developed to understand and govern summer flows. We highlight the social and political assumptions justifying how the system was delimitated and how flows were quantified. Section 2.1. first describes the manner in which the Adour-Garonne river basin authority currently represents and manages the Garonne River system.

Section 2.2. draws up a “genealogy” (Pestre, 2009) of the “Minimum Flow Requirements” (MFR) in order to understand how, and for whom, they became a norm and how they framed research issues. Section 2.3. identifies the links between MFR and a system of governance, with specific rights and responsibilities relating to the state of the Garonne River and particular financial agreements. The method designed in Section 1 was applied to the Garonne River. Section 3 displays the resulting scenarios in three different socio-environments under the same conditions of climate change. Each scenario considers a different area of responsibility: Gascony (section 3.1), the Garonne valley (section 3.2), and the European Union (section 3.3). We infer actors’ strategies and interests for the future from their past political commitments. The paper concludes with a discussion about the consistency of the resulting scenarios.

1. Building socio-environmental scenarios

1.1 Combining biophysical determinisms with actors’ deliberations in the DPSIR model

Although the evolution of environmental systems is not purely deterministic, determinist models have previously proved to be powerful tools in better understanding their biophysical behaviour. However, managers are not always at ease with the use of biophysical models. Parson (2008) argued that models failed to produce useful outputs for decision makers when the latter were mere end-users. Such a gap between science and management has become a growing source of concern for EU governance bodies, notably the European Commission, which seeks support for policy design from managers and scientists (Robert and Vauchez, 2010). In this context, environmental scenarios have become a key method of translating integrated assessment models into understandable policy options (Alcamo, 2008; Bailey, 1997; Mahmoud *et al.*, 2009; Therond *et al.*, 2009).

Scientists producing such scenarios use narratives to imagine how socio-economic drivers could affect biophysical systems. The SAS method revolves around iterative adjustments between storylines developed by participatory panels and model simulations (Alcamo, 2001; 2008). Iterations are designed to produce consistent scenarios that integrate qualitative and quantitative information validated by stakeholders involved in the process early on (Kok *et al.*, 2007). By combining determinisms and deliberation, scientists aim to integrate disciplines, improve communication on complex issues, support the comparison of policy options, test the robustness of policies, raise awareness about emerging problems, and support stakeholder involvement at the interface between science and decision making (Alcamo, 2008; Duinker and Greig, 2007; O'Neill *et al.*, 2008). Despite critiques cited in the introduction (Kallis *et al.*, 2006), proponents of the SAS method argue that it increases the legitimacy, credibility, salience, relevance, and creativity of scenarios (Alcamo, 2008; Hulme and Dessai, 2008; Parson, 2008). They advocate a dual improvement: involving more stakeholders, and making the process more explicit, through the use of causal loop diagrams, mind mapping, and quantitative models. This in turn means that environmental science and policy specialists find themselves confronted with representations that are difficult to share with outsiders. In this context, the DPSIR model is extremely useful in assessing future options with a limited set of variables. However, few scholars have reflected on the strong premises in a framework such as the DSPIR model. Indeed, this model draws implicitly upon the analogy of gravity acting on a pair of scales (see Figure 2). It represents social practices as deterministic inputs – *pressures*–, and does not discuss the specific scale used to manage the environment. We believe that the social practices and the choice of scale deserve greater attention.

The term "pressures" implies that relations between human practices and environmental degradation are as inescapable as gravity. The term "responses" suggests that it is possible to redress the balance, but does not take into account the various political processes and contexts in doing so. Both terms overlook the fundamental difference between social and biophysical relationships: whereas biophysical processes are governed by necessary and/or sufficient causal relations, "most human decisions, most political decisions involve (…) non-necessary and non-sufficient causal relations" (Trottier, 2006). The terms "pressures" and "responses" conceal conflicting accounts and responsibilities relating to environmental degradation.

The Pressures-State-Impacts part of the model deals with one definition of environmental degradation, whereas different groups have different interpretations. On the Garonne River, for example, some would argue that eutrophication relates to the intensive production of corn, while others would contend that corn production is a given and eutrophication relates to insufficient summer flows for diluting unavoidable seepages. Forsyth's notion of problem closure (2003) refers to the social and political processes involved in deciding what is given, what is not, and what are the relevant boundaries to define a specific problem. The DPSIR framework does not open the problem-closure to a pluralistic discussion, because the Pressures-State-Impacts part of the model describes the physical world as given. The implicit alignment of political scales with physical ones is problematic. This relates to Hart's broader critique of the "impact model" in which "time appears as an active force, and space as a passive recipient or container" (Hart, 2002 :49). In the DPSIR model, time is only considered within the temporality of the biophysical process at stake. The model ignores the fact that environmental systems – notably in European contexts – are historically co-produced by entangled social and natural processes.

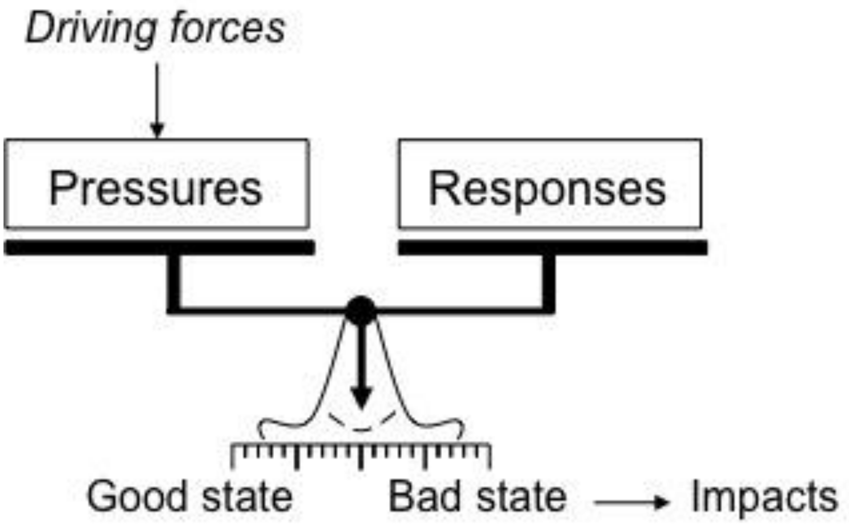

Figure 2: Representing the DPSIR approach as implicitly drawn upon the analogy of gravity acting on a pair of scales, with responses compensating pressures.

1.2 Dealing with moral values within the DPSIR iron cage

Some sceptics may wish to define the causalities and boundaries of a socio-ecological system with value-free and neutral science. However, scientific knowledge production already has values and politics embedded in its very making (Forsyth, 2003; Pestre, 2009). Using this knowledge to build scenarios for the future requires additional social and political assumptions. De Vries & Petersena (2009) and Garb *et al.* (2008) have stressed the essential link between scenarios and values.

Sharma *et al.* (2005) adopt an overarching perspective, integrating values and decisions as internal factors of the system they examine, whereas Patel *et al.* (2007) hold that values are external. They argue that scenario development engages stakeholders in negotiation, empowerment, and social learning, possibly changing their values. Most environmental scenario developers adopt a Habermassian perspective on deliberation, suggesting that the earlier stakeholders with different perspectives become involved in the process, the better they take ownership of the method. For instance, Wilkinson & Eidinow (2008) seek consensus through communication and discussion, based on the assumptions that people taking part in the debate (1) will not use the power they have in the system in question, (2) will overcome their diverging interests and strategies, and (3) will be prepared to challenge their worldviews. However, the authors do not discuss the social and political framing assumed by a specific model. In this paper, we use Forsyth's (2003) definition of "framing", meaning the principles and hypotheses defining public action and debate.

Svarstad *et al.* have pointed out that the DPSIR rationality frames our values through its related spatial and temporal system boundaries, notably through "the scale at which the impacts are defined" and "the scale of the responses and driving forces affecting this system" (2008:117). In order to quantify the water balance, hydrological models — within the scope of DPSIR — are primarily focused on watershed areas. Within such boundaries, water resource scientists investigate a wide range of environmental elements considered at risk from the degradation of water resources: fish, riparian forests, and water users (Fassio et al., 2005; Ledoux et al., 2005; Neal and Heathwaite, 2005). However, the political boundaries that are relevant in tackling driving forces and designing responses may differ from hydrological limits. Likewise, relevant timescales for studying hydrological patterns and the extent of a political body's effective remit may not correspond.

Because it adopts the definition of scale used in biophysical science (Gibson *et al.*, 2000), the DPSIR framework overlooks the *politics* of scale (Brenner, 2001) and the *relational* definition of scale when it comes to policy-making and policy-delivery (Jones *et al.*, 2013; Swyngedouw, 1997). These critical human geographers created such concepts in order to emphasise that territorial forms of policy-making and policy delivery are neither self-evident nor natural. These are what are known as "territorial claims" supported by actors who fight for legitimacy and responsibility over water management by arguing that governing water

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makes sense at their level, on the territories within their jurisdiction. For instance, the legitimacy of the Adour-Garonne river basin authority having the right to collect taxes from water users at basin *scale* was not accepted until powerful local stakeholders gave their assent. By aligning the political scales of driving forces and social responses with the biophysical scale of hydrological processes, the DPSIR framework silences political claims levied on territories. It fixes environmental systems in a-temporal and apolitical representations, and limits the scope of human agency, i.e. the capacity of human beings, individually and collectively, to make choices and act in the world. Referring to Max Weber's famous metaphor, we may say that the DPSIR rationality has become an iron cage in which our understanding of relations between humanity and its environment seems imprisoned.

1.3 Escaping the DPSIR iron cage

There are at least two ways to challenge the DPSIR approach in order to maintain pluralistic worldviews on the environment.

The most radical one – which is beyond the scope of this paper – consists in challenging the dichotomy between nature and society. This involves denying the relevance of categories such as "human pressures" and "natural state", and focusing instead on other ontologies (Haraway, 1991; Swyngedouw, 1999). Scholars engaged in social studies of science and critical political ecology have fruitfully explored this perspective by analysing how conceptualisations of socio-natures came into being, and might have become hegemonic by marginalising alternative visions about the relations between societies and their environments. These scholars have addressed how things could have been different had expertise and power developed differently, but they scarcely engage themselves in building scenarios for planning water management.

The approach used in this paper is less radical. It keeps the artifice of distinguishing nature and society for its analytical power, while placing social and political relations at the core of each scenario. The method consists in (1) identifying particular levels of water governance with the corresponding social and political coalitions whose legitimacy relates to a specific territory – continent, state, region, watershed …– and for which they produce political discourses; (2) producing several DPSIR models, that correspond to the knowledge needs of these levels of governance. Instead of bringing biophysical models into society by means of participatory workshops, we echo Garb *et al.* (2008) in arguing that it is possible to bring society back into scenarios in the first instance – i.e. starting from levels of governance– and then discuss the biophysical consequences of such governance. This change in method provides a clearer insight into stakeholders' interests, values, and power relationships relating to territorial and water management. This means that stakeholders taking part in scenario building are able to engage in more pluralistic discussions.

Our method elaborates on two strands of social theory dealing with power and quantification. It first draws on Michel Foucault's concept of *biopolitics.* Governing, according to Foucault, involves the capacity to imagine and implement measures and discourses structuring and shaping the field of subjects' possible actions, the capacity to impose metrics and to create institutions to manage them. Foucault identified various governance technologies for regulating and controlling one's own conduct and that of others. *Biopolitics*, or power over life, is one of them. It entails governance practices which aim to sustain the productive and reproductive capacities of population groups. Foucault held that neoliberal governments tend to limit their action to the implementation of market-based systems of regulation targeting guiding norms and good practices. Noting that such norms were premised on universal biophysical knowledge optimising individual and collective potentials, Foucault typically called this form of government *biopolitics* (Foucault, 1978-79). *Biopolitics* avoids coercive action and authoritarian decisions. Instead, it tends to convince individuals to make the optimum their own. Subjects are supposed to evaluate practices – theirs and others' – in terms of gains and losses of potential.

We argue that DPSIR is a particular form of *biopolitics*, targeting an optimal environmental system. It does not prohibit harmful practices, but rather encourages their effects to be compensated for. It promotes a "good environmental state" heralded as a collective optimum predicated on universal knowledge. Yet the optimal state of the environment is rarely consensual. For instance, fluvial connectivity promoted for fish migration may be opposed for reasons of economics and risk assessments. While different DPSIR models can be designed for different criteria, the approach cannot account for all environment problems. *Biopolitics* only applies to resources threatened with depletion that can be restored, for which an economic optimum can be calculated. It ignores irretrievable losses while requiring quantifiable compensation. It consequently excludes those social groups refusing compensation. Our methodology for building scenarios consists in identifying which social and spatial configurations are going to support which DPSIR models. According to Alatout (2006), territories and collective identities are born of a process of co-production which shapes power relations. Following Alatout's bio-territorial conceptualisation of power, we propose to make explicit connections between territories, political powers claiming legitimacy over those territories, and the DPSIR models whose biophysical boundaries and definition of impacts match the political and territorial claims of such powers.

The second strand of social theory we build on relates to science and technology studies (STS), notably the concepts of co-construction of science and social order (Jasanoff, 2004). By social order, Jasanoff means the social norms and hierarchies associated with specific modes of governance and power. Her concept of co-construction grasps the process by which new knowledge legitimates new power and *vice versa*. It allows us to look at the links between political and territorial claims likely to use biophysical knowledge to foster a neoliberal management of natural resources. We imagine credible coalitions likely to orientate the purpose of scientific inquiry given their motivations and possible allies (Callon, 1986; Latour, 1987; Star and Griesemer, 1989). Porter (1995) studied the political, cultural and political contexts fostering quantification and argued that the "trust in numbers" is specific to coalitions challenged by powerful outsiders. In other words, the participants most likely to engage in DPSIR modelling are not members of well-established institutions but rather representatives of weak coalitions or institutions endowed with new jurisdictions. STS literature abounds in storylines explaining the stabilisation of quantitative environmental models in a specific context of politics, geography, and access to natural resources (Goldman *et al.*, 2011) in which social scientists may find inspiration for constructing political scenarios. For any restorable resource threatened with depletion, it then becomes possible to understand the knowledge required to control it through geographically grounded *biopolitics* within a DPSIR model.

This method sustains an interdisciplinary and pluralistic dialogue with modellers. When used in retrospect, it sheds light on the social and political coalitions who found particular biophysical models useful for the governance of water. When used as a foresight tool, it helps us to consider other models likely to match the concerns of actors whose legitimacy is grounded in other levels of governance.

The method was tested on the Garonne system in two ways. First, in retrospect, the method pinpointed the historical co-production of the current dominant representation of this basin and the advent of the coalition of stakeholders who now governs water issues in the area (results presented in section 2). Following this, the method was applied as a foresight tool, with three alternative scenarios generated against a simulated backdrop of climate change (results presented in section 3).

2. Biopolitics of the "minimum flow requirements" in the Garonne system

2.1 The Garonne River system from the standpoint of the Adour-Garonne river basin authority

The Adour-Garonne river basin Authority (AGA)[2] is a state-supervised organisation responsible for the collaborative planning of water use and pollution control within the Garonne basin. The key objectives contained in AGA's master plan are to secure drinking water supplies and protect aquatic life by preventing low flows, while at the same time limiting adverse effects on hydroelectric power stations and farming. The Garonne River plays a crucial role in the provision of drinking water between Toulouse and Agen. Water is also essential for run-of-the river plants and hydroelectric dams located on the Garonne and its main tributaries. Most power production comes from upstream dams, from which water is released to meet demand for electricity at peak times, usually during the winter. The parastatal company *Electricité de France* (EDF) operates most of these dams, as well as the two nuclear plants located on the Garonne River and estuary, Golfech and Le Blayais. Golfech accounts for most industrial abstraction upstream from the Gironde estuary.

Between the 1970s and 1990s, the area of land given over to maize production more than tripled. This was made possible by the work of the formerly state-owned *Compagnie d'Aménagement des Coteaux de Gascogne* (CACG) tasked with developing irrigation in Gascony on the left bank of the Garonne River (see Figure 1). Summer and early autumn

[2] « Agence de l'eau Adour-Garonne ».

flows have always been low between Toulouse and Agen, even before irrigation developed in Gascony and before the construction of the Golfech nuclear plant. Proponents of the dam project located at Charlas have long argued that it would secure instream flow during the dry season.

Dams in the basin store late autumn and early winter rainfall as well as snow melt in spring. Irrigation is mainly for wheat and maize, with a high water demand in June, July and August. In September and October, the Garonne River experiences what can be called natural low flows before rainfall resumes later in the season (see table 1).

	Spring	Summer	Autumn	Winter
Garonne flows	High (March-May)	Average flows (June) to low flows (mid July-August)	Low flows (September) to very low flows (October)	Average flows (November) to high flows (December) and possible low flows (January-February)
Climatic explanations	Important rainy periods associated with snow melt.	End of June: rainfall stops, and end of snow melt.	Beginning of October: water tables are drained. Mid-September – End of October: rainfall returns.	November-December: rainfall increases. January – February: winter low flows, due to low rainfall, without any snowmelt

Table 1: Detailed Garonne River regime in an average year, upstream the confluence with the Tarn River (Fernandez, 2013).

In line with the DPSIR model, the AGA master plan[3] adopted in 1996 by the Committee of the Adour-Garonne river basin[4] required water users to respect "Minimum Flow Requirements" (MFR) in the Adour and Garonne Rivers and their tributaries, in order to limit aquatic environmental impacts. The committee drew up action plans to achieve this goal. MFRs are defined by the master plan as "flows above which the normal co-existence of all

[3] « *Schéma directeur d'aménagement et de gestion des eaux* ».

[4] "*Comité de bassin Adour-Garonne*".

uses and the good functioning of the aquatic environment are guaranteed, and which must thus be secured every year during the low water period with defined tolerances" (Comité de bassin Adour-Garonne, 1996). MFRs are said to be based on the modelling of "natural" flows, i.e. an estimate of the flows which would occur in the absence of anthropogenic pressures. Interestingly –according to the models used–, without reservoirs, this target value could never be attained all year long in the Garonne, even if there were no human withdrawals!

AGA considers that MFRs optimise summer and early autumn daily flows, recharging aquifers used for drinking water purposes and sustaining aquatic life from July 1 to October 31 without excessively impairing economic activities. Although the plan does not explicitly refer to the DPSIR model, its general logic is the same, and can be expressed in DPSIR language: MFRs are thresholds allegedly defined by experts between the good *state* and the problematic *state* which *impacts* water uses and aquatic life; on the Garonne, hydropower and irrigation are presented as the main *pressures* affecting river flows; they are understood to result from *driving forces* such as climate –rain and snowfall patterns, evaporation– as well as sector-based markets and policies. Today, political *responses* consist of (i) contractual arrangements for releasing water from hydropower dams, (ii) construction of new dams, and (iii) sector-based water savings (see Figure 3). However, this type of framing has not always prevailed.

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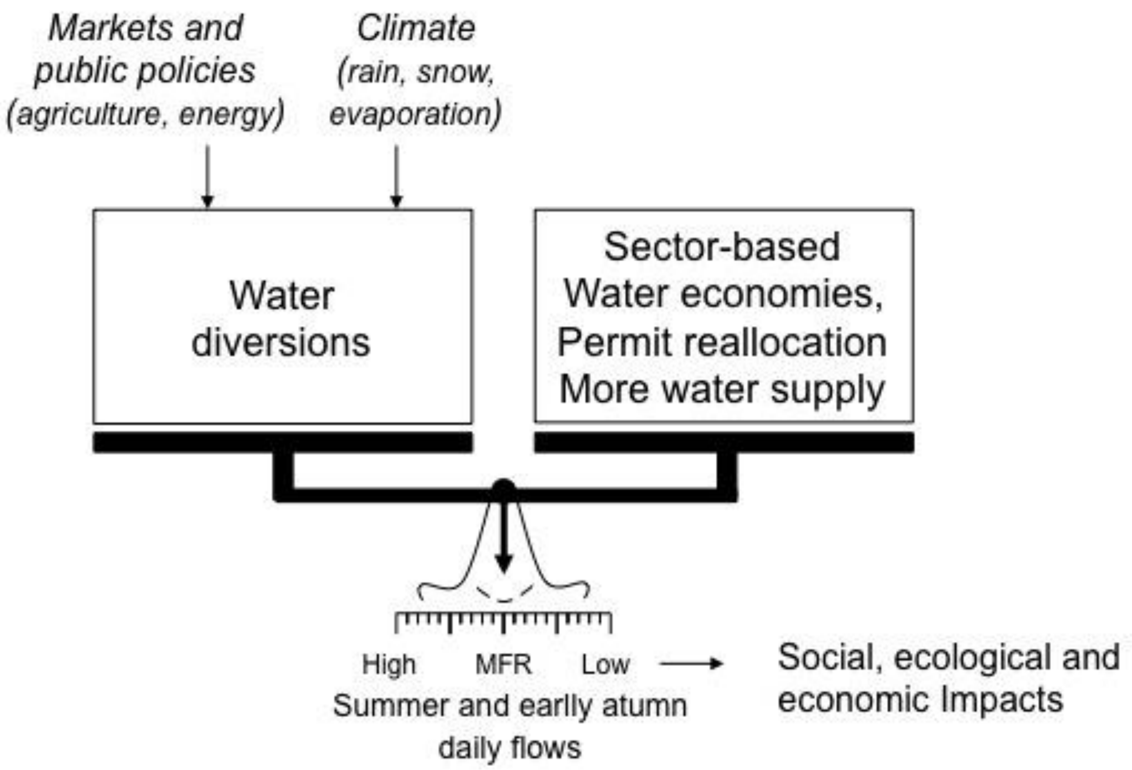

Figure 3: The minimum flow requirement (MFR) of the Garonne River implicitly draws upon a DPSIR model.

2.2. How "Minimum flow requirements" became the norm

French river basin authorities (*Agences financières de bassin*, later renamed *Agences de l'eau*) were created in 1964 to collect pollution charges at river basin level and fund restoration. As Barraqué emphasised, "enforcement of water regulations and issuing of permits [were] not in the hands of the *Agences*, they [could] only try to persuade water users to increase the level of their efforts through the investments they subsidise[d]. This [resulted] in the funding of point pollution reduction or water supply increases rather than reducing pollution discharges or water demand" (2000 :219). To explore their leeway for action within such constraints, river basin authorities favoured quantification and commensuration processes linking quality and quantity issues: diversions and pollutions were *pressures*, reducing the self-purifying capacity of rivers. Treatment and dilution were appropriate *responses* (see Figure 4). For the Garonne

River, water politics loomed large in the quantification process developed by the experts of the river basin authority.

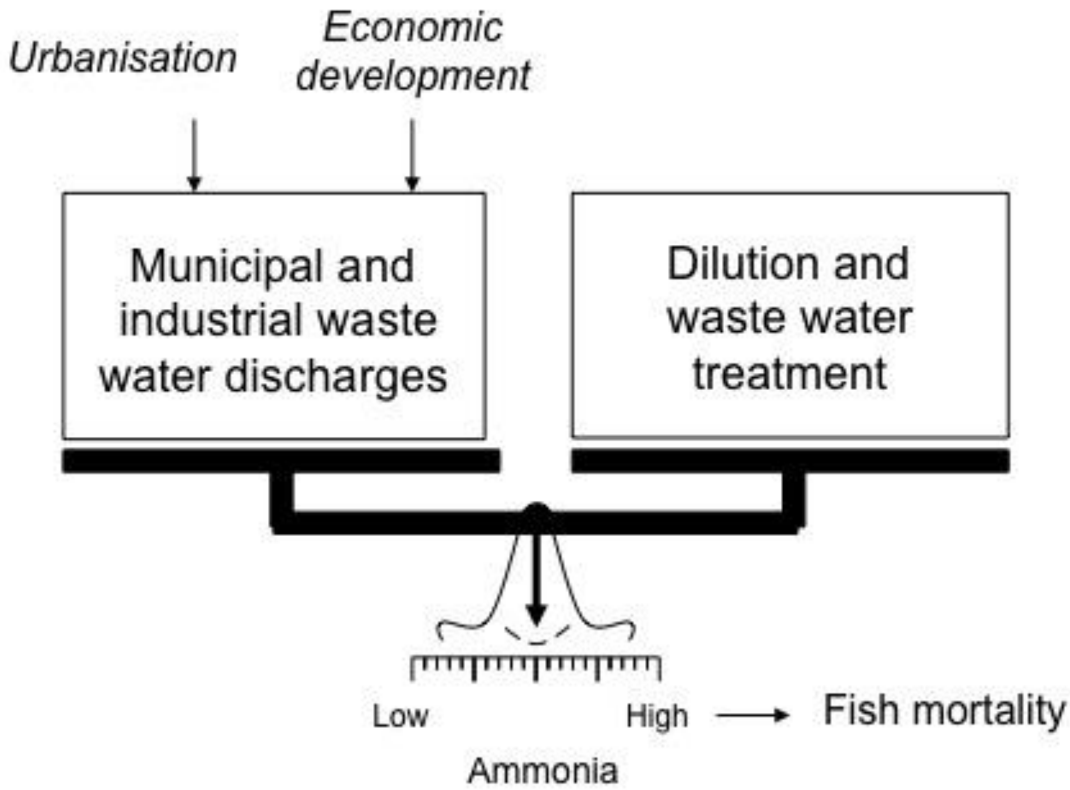

Figure 4: Conceptual representation of the solutions developed by the Adour-Garonne river basin authority for managing point pollution in the 1970's.

In the Garonne river basin, given the political influence of power producers and irrigators, AGA considered their existing permission to take water from the river to be non-negotiable. Water abstraction was sparsely metered, and dams were not subject to river basin levies. Hydrological experts of the river basin authority considered that the remaining river flow after such non-negotiable abstraction constituted the *state* of the river in summer. In the Garonne River, fish were mainly threatened by ammonia discharged directly into the river by producers of fertiliser or resulting from agricultural nitrate runoff transformed into ammonia in polluted water. The chemical and agricultural sectors were powerful enough to also impose their practices as non-negotiable. However, through its policy of subsidies, the river basin authority was able to encourage cities to treat their wastewater in order to reduce the pollution in the river, and the transformation of nitrate into ammonia. In the 1970s, AGA proposed an initial definition of the MFR, based on the maximum amount of wastewater that could be discharged while still protecting fish.

In the 1980s, while the AGA had little control over power generation and irrigated agriculture, their impacts on water were significant and increasing. In the late 1980s, recurrent droughts created severe tension among water users. As environmentalists gained power throughout France, the state reinterpreted water rights as defined in the leasing contracts of EDF. The State compelled EDF to release water from its dams without any compensation for the financial loss incurred. Had these releases occurred during the winter, the losses would have been negligible, as the electricity generated by the process would have been easy to sell. Unfortunately for EDF, this demand came during the less busy summer period, meaning that large quantities of electricity were generated, but without anyone to use it. In subsequent years, EDF agreed to join the levy system and observe AGA's rules, sharing the cost of additional dams with other water users.

In the mid-1990s, farmers using water for irrigation agreed to join the AGA system as national and European policies changed, reducing financial support for irrigation infrastructure. Farmers implemented metering systems and started paying levies for MFRs. Nevertheless, securing MFRs challenged neither the water diversions of EDF nor those of irrigated agriculture – the result was in fact quite the opposite. EDF claimed and obtained additional river basin levies for this purpose, so as to be paid for water released from its reservoirs during low flow periods. At the same time, AGA worked out new justifications for dam building which proved beneficial to agriculture. MFRs therefore became the norm, enthusiastically supported by powerful stakeholders.

During this period, the definition and modelling of MFRs underwent significant changes, as discussed in the following section. The relevance of the DPSIR model shown in Figure 4 faded away, and the system became the summer flow balance as we know it today, already shown in Figure 3.

2.3. How minimum flow requirements blurred categories of water abstraction

Since the beginning of the 1980s, the CACG has promoted the construction of a dam at Charlas to extend the irrigated land area in Gascony. During the 1980's, AGA added a second objective to this dam: preventing low flows upstream of Toulouse in the summer. There were clashes between supporters and opponents of the dam. To resolve these conflicts, the Ministry of the Environment requested a comprehensive environmental study, whose aim was to assess natural low flows, and, where relevant, the necessity of compensating structural deficits. Thanks to a series of assumptions, at the end of a four-year study, the MFR were aligned with estimated natural low flows. Estimates of average natural low flows throughout the summer were based on a series of statistical calculations which eliminated the distinction between periods that were influenced by irrigation –until late August–, and those that were not –September–October–. This method artificially decreased the impact of irrigation, particularly during early summer. The individual responsibility of stakeholders did not matter to the river basin authority. AGA was much more concerned by the fact that sewage treatment plants had once been designed according to instream flows influenced by dams, and required a secure instream flow in September. By disregarding time periods and accountable water users, the comprehensive environmental assessment convinced state officials, EDF, and the CACG that it was in their own interests to meet high MFR from late June to late October (Fernandez, 2013 (in press)).

Ironically, the decision to build the Charlas dam is still pending. Meanwhile, MFR have become hegemonic in the Garonne watershed. Only by searching in archives may one discover the original assumptions on which the need for such flow objectives was based (Fernandez, 2009). When an explosion at the large fertiliser plant in Toulouse, AZF[5], occurred in 2001 and the factory was not rebuilt, no one stated that the Garonne MFR had been defined in order to dilute its contribution to ammonia discharges into the river. All water managers had accepted the MFRs as given. They had learnt to take decisions according to it. It had become a *biopolitical* constant. As one manager at AGA said: “recalculating the MFRs? This would be like opening Pandora’s Box” (Fernandez, 2009:315).

Flow control in the Garonne watershed does not therefore only rely on inevitable determinisms. Strong assumptions were also made. The biophysical model used is not the only one possible, but rather a model useful for powerful actors claiming jurisdiction over the Garonne watershed. It is the product of a series of discontinuities, contradictory experiences, contingent historical events and power asymmetries. It does not necessarily have to remain in place in the long term. To help renew reflection on the links between models and politics, considering territorial claims expressed by other coalitions would probably put the spotlight on other natural resources, or other ways of dealing with water. Such an intellectual exercise is a potentially useful way of exploring what could happen in the future as our climate

[5] The « Grande Paroisse » factory in Toulouse, also called AZF, the leading French fertiliser producer and property of TotalFinalElf group, was built in 1924 and enlarged in the 1960’s. On 21st September 2001 a shed at the factory containing 300 tons of ammonium nitrate exploded, producing a large crater, killing 31 people, injuring more than 4,500 people, and destroying 27,000 buildings (Fernandez 2009: 293-321).

changes and less water is available. It may expand strategic options, and demonstrates heuristic value in orientating future modelling research. We illustrate this point in the next section.

3. Building scenarios for future flows in the Garonne River

European water policy makers and water managers use the DPSIR model to assess impacts of climate change and design adaptation policies[6]. Consciously or unconsciously governed by the tool they have crafted together, water managers on the Garonne River focus on the evolution of MFRs, rarely questioning their construction. Trained and duty-bound to work within the river basin boundaries, they are not in a position to see how factors beyond such limits could become crucial in the future.

The scenarios presented hereafter are narratives describing possible future courses of events, sequences of developments, decisions and turning points leading to contrasted images of the Garonne valley in the 2030s. They were constructed during a training course on future studies for post-graduate students in water management (AgroParisTech, Montpellier, France), presented to and discussed with representatives from the Adour-Garonne river basin authority and the “Joint Board for Studying and Managing the Garonne” (SMEAG)[7]. What we consider passive in one scenario becomes our response level in another scenario. What we consider as

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[6] The European Water Framework Directive (2000/60/EC) is based on a DPSIR approach. It requires a systematic characterization of pressures and impacts affecting all water bodies as well as a cost-effective planning of responses.

[7] The French acronym SMEAG stands for « *Syndicat mixte d’études et d’aménagement de la Garonne* ». The SMEAG is a joint board of two riparian *régions* and the four riparian *départements* of the Garonne River, which was set up in 1983 to (1) improve water quality and water availability, (2) prevent flooding and (3) foster the economic and environmental development of the Garonne valley.

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external factors in one case can be included in another. The territorial powers we consider are either nested within one another, or partially overlapping. We seek to create legitimate, salient, credible, and relevant scenarios, basing their rationality upon social theory.

Using the DPSIR approach, several models supporting the decisions of contrasted territorial powers can be created. Let us imagine that, as experts claim (Caballero *et al.*, 2003), climate change would have the following consequences on the Garonne hydrology: (i) a decrease in mean low water levels, (ii) a decrease in snow cover and an increase in rainfall, (iii) changes in biodiversity and (iv) an increase in average temperature. In the three following scenarios we reflect on how different socio-political orders with jurisdiction over different territories and activities might react to such changes, and what type of DPSIR framing they could support. The three scenarios vary according to which territory is the first to implement changes in management of the Garonne River: (1) Gascony, (2) the Garonne Valley, and (3) Europe. They are summarised in Table 2. The stakeholder coalitions we imagined in these three scenarios were not chosen at random. They were selected following a careful analysis of stakeholders, resources, territorial claims, and history, pointing to a particular indicator being adopted by a particular stakeholder.

Territorial base of the scenarios	Definition of the problem at stake	Situation of the MFR	logic of compensation
Gascony	Fostering a low carbon economy	MFR respected	Carbon market
Europe	Human health threatened by pesticides	Lower MFR	Water users paying for river remediation
SMEAG	Ecological excellence	Higher MFR	Inhabitants paying for ecological habitats

Table 2: Summary of the three scenarios built.

3.1 Gascony takes the lead: controlling carbon dioxide emissions

This scenario focuses on the political stakeholders who are situated at the level of governance of *régions* and *départements,* and who exercise some territorial power over Gascony, the plateau located north of the Pyrenees on the left bank of the Garonne River. Gascony corresponds to the administrative boundaries of two French *départements:* Gers and Hautes-Pyrénées (see Figure 5), shareholders of the regional development company, CACG, since the 1990s. These stakeholders have opportunities, interests, and resources to shift Gascony's economic development away from its vulnerability to low summer flows, steering it towards solar energy, biofuel, and forestry. They are likely to "trust numbers" (Porter, 1995), being in a weak position towards powerful water users and the state. With less competition for the use of summer flows, hydrological knowledge in such a case will not be as useful in legitimising their power. Instead, these stakeholders may seek legitimacy from a biopolitics of carbon capture. Such a scenario opens the discussion about water resource planning to stakeholders who, while not water specialists, are able to design and implement policies compatible with sustainable water use. It shifts the logic of compensation away from the water sector towards a carbon economy.

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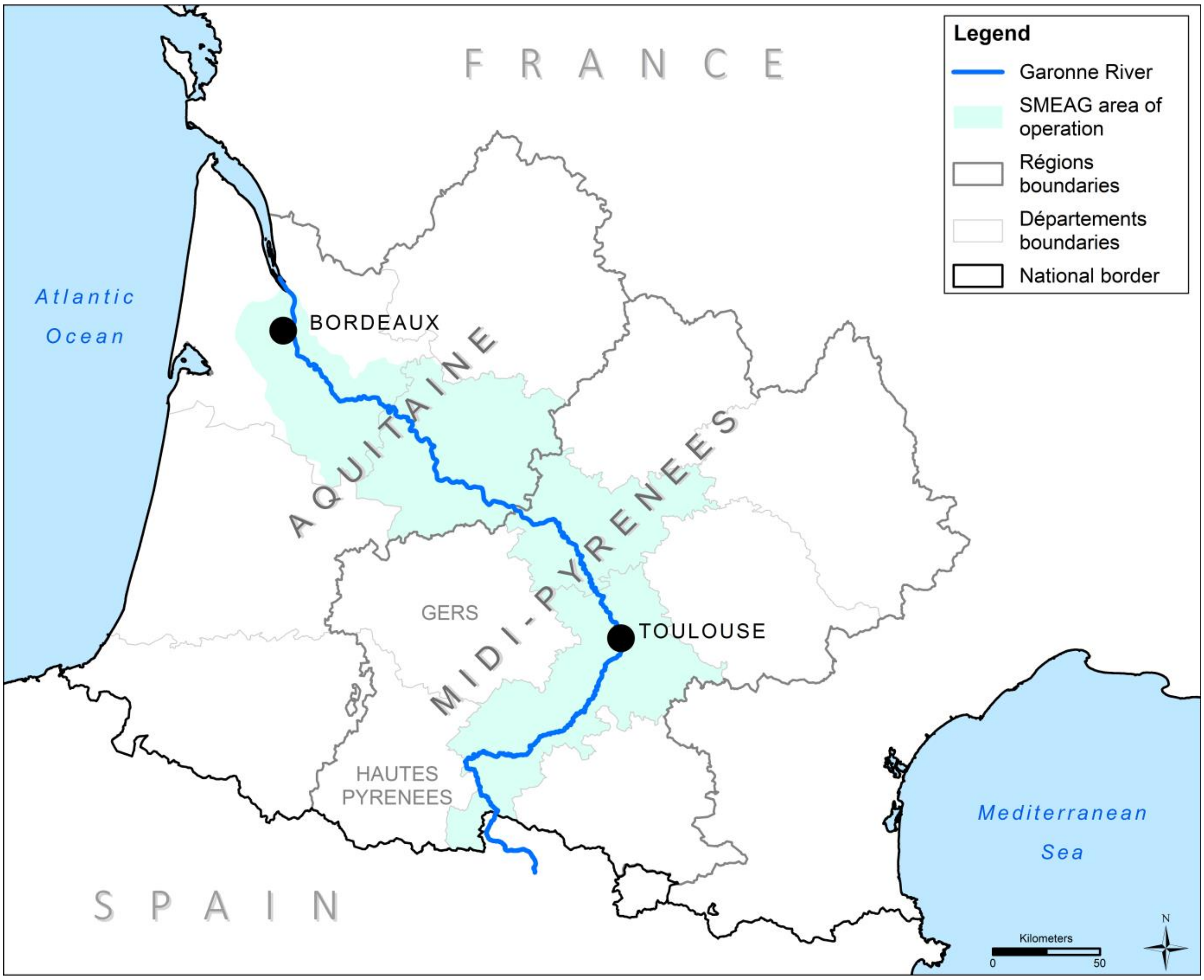

Figure 5: Gascony (administrative boundaries of the *départements* Gers and Hautes-Pyrénées within the *région* Midi-Pyrénées), and the territory managed by the Joint Board for Studying and Managing the Garonne, SMEAG (Decherf, 2013).

Without additional funds for dam building from either AGA or the State, Gascony could face lower water levels in hydropower dams, and lower flows in summer. Local authorities may count on their longstanding assets, the Pyrenean forest and the CACG, to adapt. The engineers of the CACG, who once involved farmers in irrigation and maize production at the end of the 1970s, could help maize producers to adapt to early-maturing crops with the support of AGA and the Gers *département*. Changed practices and innovations could be encouraged by subsidies previously dedicated to sustaining MFR during low flow periods. In 2020, the EU might adopt a carbon tax to be paid by Member states which France could pass on to *départements* and *régions*[8]. With the support of the Midi-Pyrénées region, the Gers and Hautes-Pyrénées *départements* could avoid this tax by jointly investing in a large-scale facility to produce timber. Forestry would benefit. In the past, strong railway trade unions have prevented unprofitable lines in the Midi-Pyrénées from being shut down. What used to be considered an obstacle to modernity could ironically become a trump card with regards to carbon emissions.

The costs of renewing the main infrastructure for electricity production and transmission will be a critical issue throughout France in the 2030s. The Golfech nuclear plant on the Garonne could be among the installations under scrutiny. Its production could have been sold at a high price if exported to Spain, given limited local consumption. However, existing lines into Spain have limited export capacity. There is long-standing local opposition to the construction of new lines in Gascony. One could imagine that after fierce conflicts, nuclear production at Golfech could stop. The increase in energy costs could favour the development of local energy production units, notably based on solar energy and biofuel. In such a scenario, less water would be needed for power production all year round. Relying on early maturing crops, irrigation could use spring flows. Despite significant changes in rain and snowfall patterns, natural resource management in Gascony would no longer be a question of water. Reducing the concentration of carbon dioxide in the atmosphere could become the dominant issue.

Using a DPSIR approach, we could illustrate this new form of *biopolitics* as shown in Figure 6. In this scenario, *départements* would support the costs of a carbon ecotax. Many would

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[8] In France, *départements*’ local authorities are in charge of road development and maintenance as well as local transport and low-cost housing. *Régions* are in charge of railways.

inherit carbon-intensive technologies. Some of them, however, such as Gers and Hautes-Pyrenees, could make a difference thanks to their agricultural and forestry potential. They could minimise their contribution to the carbon ecotax by investing in alternative sources of energy and carbon capture.

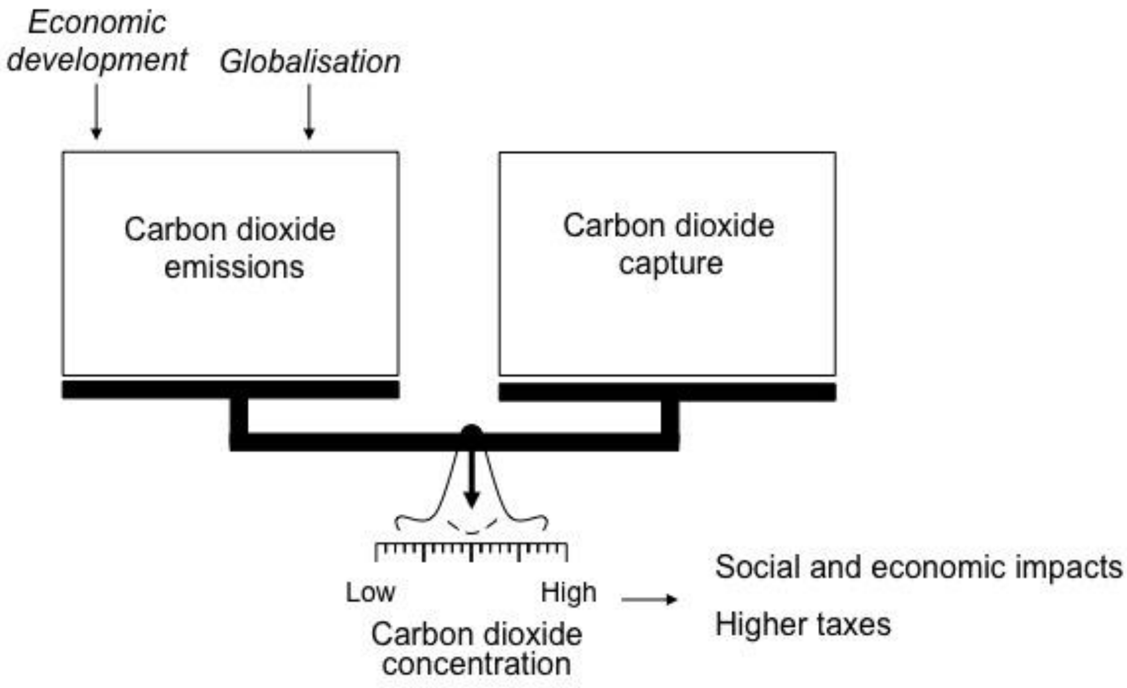

Figure 6: Optimising the carbon dioxide concentration in the Gascony-centred scenario.

3.2. The "Joint Board for Studying and Managing the Garonne" takes the lead: managing the sturgeon

This second scenario focuses on the watershed level of governance at which the "Joint Board for Studying and Managing the Garonne", SMEAG (see footnote 7 and Figure 5), exercises limited territorial powers along the Garonne River, without the right to levy taxes. If supported by new residents in the area, SMEAG would have the opportunity, motivation, and resources to foster ecological connectivity as a main political goal. In order to sustain good ecological conditions for sturgeon, SMEAG could "trust numbers" and negotiate financial agreements with hydropower managers and the irrigation sector for water release when ecologically needed. Such negotiation could be supported by a DPSIR model combining hydrological and ecological knowledge and could help implementing a biopolitics of sturgeon. In such a case, minimum flow requirements may be increased.

Southwest France has long attracted tourists and retired people from all over Europe. More recently, young people coming from Northern Europe have also settled north of the Garonne valley in the Dordogne valley, which runs from central France to the Atlantic down to the same estuary. They are more concerned by environmental issues than their long-settled neighbours and more likely to commit themselves in associations to promote environmental quality (Gilbert, 2010). One could imagine that the same trend could expand into the Garonne valley, reinforcing existing local environmental activism.

One could also imagine a long series of CAP reforms, leading to a progressive liberalisation of the agriculture sector within the European Union. Farmers in the Garonne valley would thus face uncertain markets while producing grain, i.e. low value added crops. In this context, a significant proportion of farmland could be abandoned between 2010 and 2015. Remaining farmers might be willing to diversify their output away from maize provided they could find profitable local market outlets. In doing so, they may find support from the SMEAG. This Joint Board is what Barraqué (2000) would refer to as a “traditional authority” in contrast to the river basin authorities, which are “not directly responsible for implementing an action programme”. The Joint Board receives funding from *départements* and regions in order to initiate development projects. It would certainly support initiatives in favour of high quality farm products, in order to maintain the traditional landscape and “*terroir”* which sustain the attractiveness of the region, especially from a culinary point of view.

As maize production decreased, so would demand for irrigation water in the dry season. Farmers would lose interest in an additional dam at Charlas. The SMEAG might take this opportunity to promote continuity and connectivity of the Garonne from head to estuary. Sturgeon could become its flagship species. Migrating fish were once plentiful in the rivers of Western Europe. The several thousand individuals remaining today originate from the Gironde estuary. Intensive fishing and degradation of river habitats severely impacted the fish population in all other basins as well as in the Garonne River. However in 1995 fish biologists near Bordeaux managed to produce European sturgeon offspring in artificial conditions. This technology allowed fish restocking of the Garonne and the Dordogne Rivers. Such endeavours have already been great publicity for the region. Another species of sturgeon (Russian Sturgeon) is locally farmed for its eggs. The region Aquitaine has supported this production locally through the brand "*caviar d'Aquitaine*", in keeping with southwest France's tradition of "*haute cuisine"*. It is an alternative to the consumption of indigenous sturgeon, which is prohibited due to levels of cadmium in sediment found in the rivers and estuary.

Nonetheless, sustainable management of the indigenous sturgeon could label the Garonne valley as a model of ecological modernisation, provided morphological modifications of the upstream basin were mitigated. More instream flow downstream of hydropower dams would be necessary. When dam leasing contracts come to be renewed, the SMEAG and its counterpart for the Dordogne River might renegotiate rules for water releases from the hydroelectricity dams on the Garonne and Dordogne Rivers.

The sturgeon could become a symbol of the landscape quality of the Garonne and the Dordogne Valleys which are connected by the Gironde. Without a major change in industrial activity and lower employment in agriculture, economic development would hence rely on tourism and residential housing. Property values would increase and local authorities might be able to raise taxes as well. The sturgeon could epitomise the successful policy of environmental restoration which real estate agencies would turn into market value. Wealthy landowners valuing landscape amenities could support such a policy (see Figure 7).

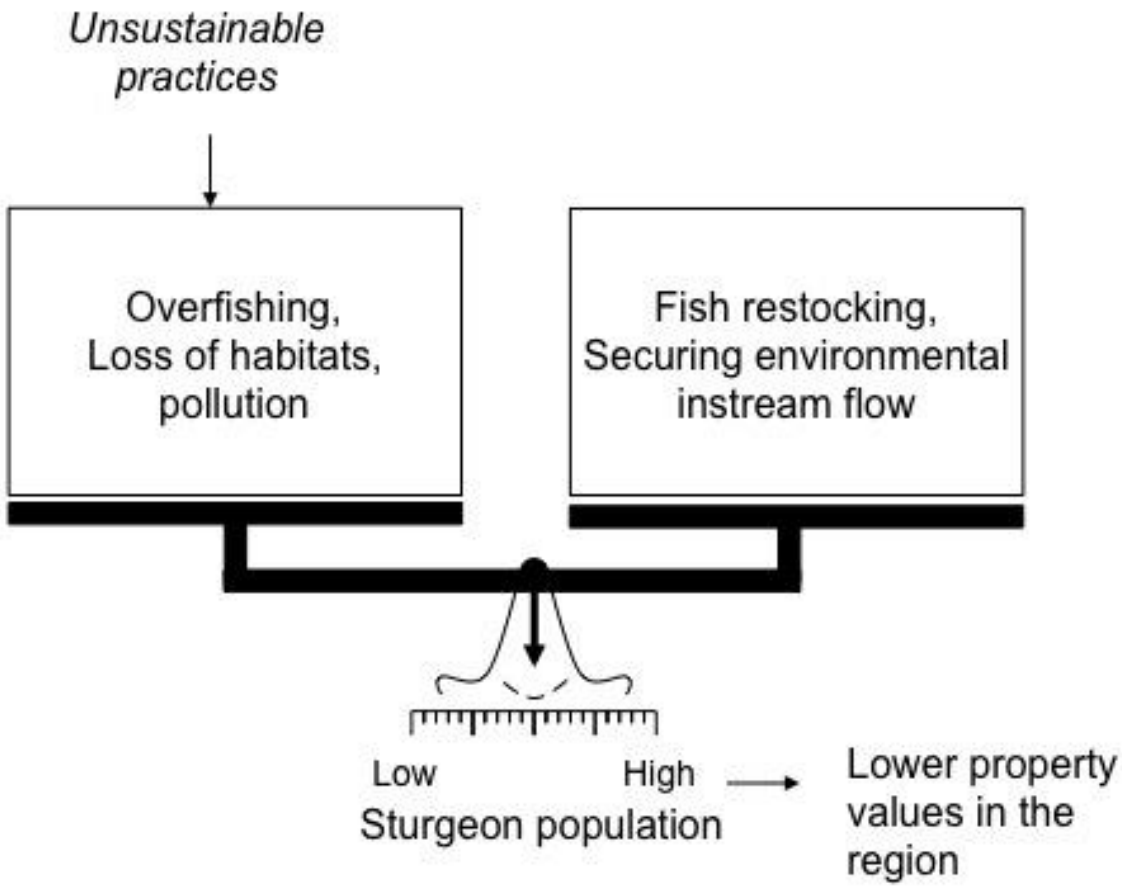

Figure 7: Optimising sturgeon population in a Garonne valley-centred scenario.

3.3. Europe takes the lead: governing pesticide levels

This third scenario focuses on institutional stakeholders situated at the European level of governance, who exercise power over the Garonne River from a distance. These actors have opportunities, motivation, and resources to set the problem of pesticides at the top of the European environmental agenda. Challenged by local powerful water users, they may admit that lower minimum flow requirements in the Garonne still comply with EU directives. They may consider human health as “the resource threatened with depletion” in a biopolitics of pesticide exposure. Facing opposition, they could rely on quantification to set standards low enough to limit health risks, but above zero to account for economic and ecological inertia. The demand for hydrological knowledge in this case may shift from summer water flows to the dynamics of pesticides at the interface between water and sediments, a process much affected by winter flows. Such a scenario shows that water managers may redefine the issue at hand to such an extent that the biophysical model built for former purposes becomes obsolete. Moreover, it illustrates the possibility to renegotiate something once assumed to be the optimal state of the system, and which used to be at the core of the biophysical model.

One could imagine that the future of the Garonne valley would largely depend on European politics. In 2015, Europeans might still be affected by the economic crisis, and may ask for more state intervention in social affairs. Climate change could exacerbate discrepancies between EU countries, and challenge European cohesion. Facing this challenge, EU leaders could rely on traditional policies which have gained legitimacy: Common Agricultural Policy (CAP) and consumer protection. One could imagine that in the coming years, new instruments for measuring water quality would be available. They could reveal high rates of pesticides in the watercourses of the main maize producing regions, such as southwest France. Studies carried out by different European laboratories might also show a strong correlation between such high rates and the risk of developing cancer. Europe-wide consumer associations could call pillar 1 of the CAP into question, despite the possible counteroffensive from the main European chemical and food industries. In 2020, the European Union could overhaul its support programme focused on intensive agriculture and redirect it to environment-friendly practices.

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Despite efforts to change land use patterns, pesticide loads in rivers and groundwater will certainly remain high for a long time to come. Ecological status, which dominates the EU water agenda today, may lose importance if the cost to maintain it becomes too high, given the impacts of climate change on ecosystems. Instead, incentives under European directives for chemical remediation processes will probably increase in order to limit the amount of pesticides in drinking water. Several processes for treating water on site – pumping, trapping or filtering water – could be tested and standardised across Europe. In France, river basin authorities would promote such techniques to improve the quality of surface and groundwater. Water charges would rise to fund remediation. Water users might accept this, provided the overall water quality improves accordingly. In the Adour-Garonne river basin, dam building might lose support. Irrigation and electricity sectors could instead negotiate greater water rights, arguing that MFRs for the Garonne River were once calculated to dilute ammonia discharge in case of an industrial hazard in the fertiliser factory at Toulouse which no longer exists. Thus, in this scenario, policymakers would tend to limit human exposure to waterborne pesticides, and would tolerate lower summer flows in the river. Considering past and present use of pesticides as inescapable practices, they would favour river and aquifer remediation to avoid public health issues (see Figure 8).

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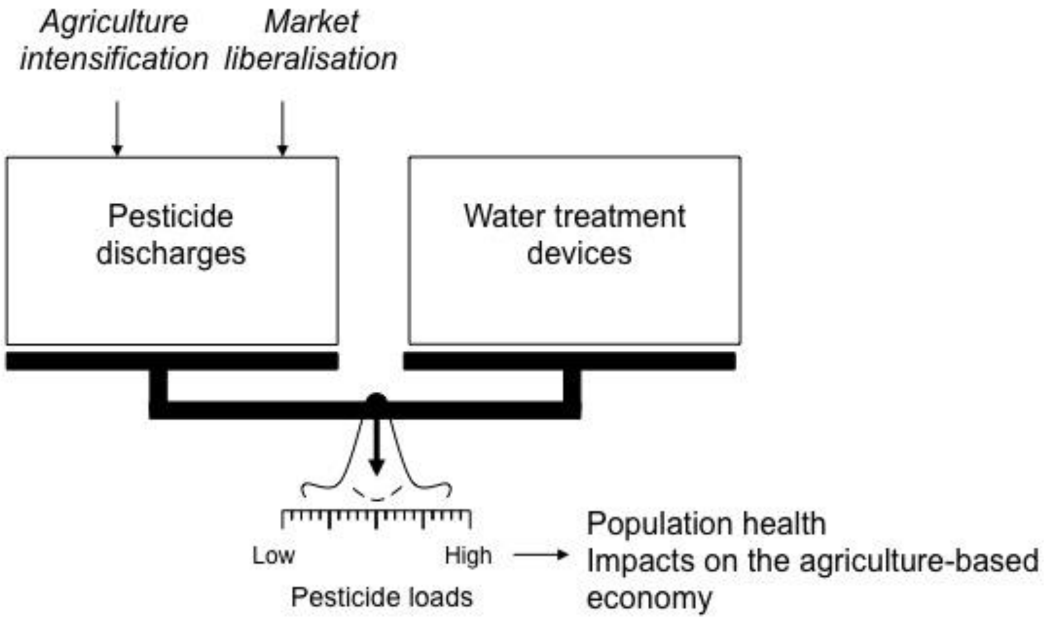

Figure 8: Optimising pesticide loads in the EU-centred scenario.

Conclusion

The Driving forces-Pressures-State-Impact-Response (DPSIR) approach has become hegemonic in European environmental policies, notably for designing scenarios for water-use planning. This approach silences conflicts over the political environmental agenda and territorial claims, while developing indicators that match specific problems and areas of responsibility. It portrays systems as separated from any social or historical fabric, and hides the political work it actually performs. Based on the “gravity” analogy, the DPSIR model claims to be neutral, whereas in reality it is highly sensitive to spatial boundaries. In this model, certain social practices and political choices become seemingly inescapable pressures or driving forces, while other practices need to be adjusted. This kind of framing might be useful in supporting a top-down decision making process, but it obviously narrows the scope of debate when it comes to imagining future scenarios for water use planning.

More specifically, the DPSIR model is rooted in three basic assumptions, which are questionable if the framework is to be used to support public debate. First, the model considers anonymous and atemporal forces, as if identifying the stakeholders behind such forces did not matter. Likewise, no attention is paid to *when* they took decisions resulting in the current environmental state, nor is any emphasis placed on *what benefit* they derived from it.

Secondly, the model assumes that environmental degradation can be compensated. It excludes irretrievable losses from the debate, whereas they may be crucial for some stakeholders.

Finally, it considers that the system is bound by watershed limits. There is however no such thing as a socio-hydrosystem embedded in the Garonne River basin.

Society is not organised according to hydrological categories. Social groups in specific geographical settings refer to different systems which combine several components, some of them relating to the Garonne and others not. Therefore, the Garonne River can be seen as one element among others in several systems. Scholars using the DPSIR framework usually consider physical laws governing a system around which social factors accelerate or mitigate such determinisms. We argue that social factors may be central to defining collective action.

The method presented in this paper enabled us to build consistent scenarios, combining natural determinism and political problem setting at different scales and in different spaces. The scenarios built with this method illustrate that the future is uncertain, not only because we do not know how a factor will evolve, but also because the future significance of this factor for society is unknown as well. These scenarios also show that water may be governed otherwise than through compensation, and that the compensatory approach may be applied to environmental topics other than water. The resulting scenarios show a diversity of governance modes and targets more likely to open the discussion to a broad and pluralistic audience than those based on a single DPSIR model.

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