water

MDPI

Article

How to Enhance the Role of Science in European Union Policy Making and Implementation: The Case of Agricultural Impacts on Drinking Water Quality

Matjaž Glavan [1,*], Špela Železnikar [1], Gerard Velthof [2], Sandra Boekhold [3], Sindre Langaas [4] and Marina Pintar [1]

1 Biotechnical Faculty, University of Ljubljana, 1000 Ljubljana, Slovenia; spela.zeleznikar@bf.uni-lj.si (Š.Ž.); marina.pintar@bf.uni.lj.si (M.P.)
2 Environmental Research, Wageningen University and Research, P.O. Box 47, 6700 AA Wageningen, The Netherlands; gerard.velthof@wur.nl
3 National Institute for Public Health and the Environment, Antonie van Leeuwenhoeklaan 9, 3721 MA Bilthoven, The Netherlands; sandra.boekhold@rivm.nl
4 Norwegian Institute of Water Research (NIVA), Gaustadalléen 21, 0349 Oslo, Norway; sindre.langaas@niva.no
* Correspondence: matjaz.glavan@bf.uni-lj.si; Tel.: +386-1-320-3299

Received: 20 December 2018; Accepted: 5 March 2019; Published: 8 March 2019

check for updates

Abstract: Throughout the European Union (EU), high concentrations of nitrates and pesticides are among the major polluting components of drinking water and have potential long-term impacts on the environment and human health. Many research projects co-funded by the European Commission have been carried out, but the results often do not influence policy making and implementation to the extent that is duly justified. This paper assesses several issues and barriers that weaken the role of science in EU policy making and EU policy implementation in the case of agricultural impacts on drinking water quality. It then proposes improvements and solutions to strengthen the role of science in this process. The analysis is conceptual but supported empirically by a desk study, a workshop, and complementary individual interviews, mostly with representatives of organizations working at the EU level. The results indicate that perceived barriers are mostly observed on the national or regional level and are connected with a lack of political will, scarce instruction on the legislation implementation process, and a lack of funding opportunities for science to be included in policy making and further EU policy implementation. In response to that, we suggest translating scientific knowledge on technological, practical or environmental changes and using dissemination techniques for specific audiences and in local languages. Further, the relationship between data, information and decision making needs to change by implementing monitoring in real-time, which will allow for the quick adaptation of strategies. In addition, we suggest project clustering (science, policy, stakeholders, and citizens) to make science and research more connected to current policy challenges and stakeholder needs along with citizen involvement with an aim of establishing sustainable long-term relationships and communication flows.

Keywords: drinking water; agriculture; EU policy; governance; integrated scientific support; water quality; nitrates; pesticides

---

1. Introduction

Safe drinking water is vital for public welfare and is an essential driver of a healthy economy. Throughout the European Union (EU), nitrates and pesticides are currently among the significant polluters of drinking water. High concentrations of nitrates and pesticides, with a long-term impact on groundwater quality, have human (drinking water) and environmental (eutrophication of groundwater-dependent ecosystems) health consequences [1,2]. In order to protect drinking water sources, and sometimes for complementary reasons, the EU has developed an extensive set of water-related directives, guidelines, and policies over the last decades. The requirements of the Drinking Water Directive (DWD) set an overall minimum quality for drinking water within the EU. The Water Framework Directive (WFD), the Groundwater Directive (GWD), the Nitrates Directive (ND), and the Directive on the Sustainable Use of Pesticides (DSUP) require member states to protect, among other things, drinking water resources against pollution in order to ensure production of safe drinking water.

One of the key points in discussions among scientists, policy makers and other actors in the last decade has been the need to develop a conceptual framework to strengthen the role of science in relation to water. This is especially important when it comes to policies involving water security as various initiatives and knowledge exchanges must be enabled in order to support EU policy making and the implementation of EU policies on a national level [3]. One of the conclusions from the European Commission (EC) report on scientific evidence for policy making is that decision makers in policy and practice typically can benefit from more use of available research-based knowledge. Yet, researchers should produce more knowledge that is directly or easily usable by various specific audiences and on all levels of practical decision making [4]. It could be argued that the limited role of science in policy making will be overcome when its complexity and heterogeneity is successfully incorporated into policy measures [5]. Moving towards more evidence-based policy making within the EU necessitates better integration and collaboration (co-creation and co-design) at the science/policy interface [6]. Many contextual, structural and cultural factors often inhibit better collaboration, such as a lack of opportunities to work together, inconsistent working methodologies used in the decision-making process, political views of national governments, socioeconomic differences, and a lack of effective communication channels between nations [4]. To adequately address drinking water security, better integration of science and policy is required at all levels of policy making [7]. The literature states that existing practices that attempt to bridge the gap between research and policy making do not provide efficient solutions [8–11]. Therefore, the EU has emphasized the importance of strengthening the dialogue between policy makers and researchers at the EU, national, and regional levels with clear scientific explanations of EU policies. Clear examples of that approach are the European Innovation Partnership (EIP) groups and WFD Common Implementation Strategies guidance documents. These principles are the key to maximizing the impact of scientific evidence in policy development and implementing policy in real life. Concepts such as multi-actor platforms are devised to stimulate improved dialogues between concerned actors including scientists, policy makers, decision makers, and affected stakeholders.

The objective of this study is to analyze and discuss the role of science in EU policy making and implementation processes concerning the agricultural impact on drinking water quality. This concerns, broadly speaking, the WFD, DWD, GWD, ND, and DSUP. Specifically, we want to identify barriers that hinder the science and research sector from having effective dialogue and cooperating in knowledge sharing from policy making to actual EU policies implementation on the member state or regional level. We argue that the science/research sector's role in policy making and implementation is vague and dispersed across different stages of the process. It also has different roles in the process, as an initiator of policy, a follower of policy or political strategies, or a participant in the public discussion. Our societal aim of this analysis is to suggest possible long-term system improvements and to encourage scientists and policymakers to develop new solutions for improving communication flow. The study, while conceptual, is based on empirical data collected by a desk study, a workshop with different stakeholders, and individual interviews with EU-level stakeholders. This paper is prepared under the EU Horizon 2020 project "Farm systems that produce good water quality for drinking water supplies" (FAIRWAY).

2. Materials and Methods

2.1. Desk Study

A desk study was carried out as a basis for the workshop and interviews. The desk study focused on the following topics: (i) agriculture and water in the EU, (ii) evidence-based policy making in the EU, and (iii) implementation of the Water Framework Directive. A nonsystematic review of relevant scientific literature was carried out using scientific databases such as Scopus, Web of Science, Science Direct and Google Scholar. Other information was obtained from websites of the EU and the internet.

2.2. Workshop and Interviews

A workshop on the "Evaluation of the issues and barriers around providing integrated scientific support for EU policy" was held in Brussels, Belgium, on 6 December, 2017. The workshop was led by a FAIRWAY project partner, the University of Ljubljana. The workshop method was based on a World Café workshop type with a duration of 3 h. The primary objective of the workshop was to discuss with representative EU-level actor organizations the role of the science and research sector in EU policy making and EU policies implementation related to drinking water resource protection against diffuse pollution of nitrates and pesticides originating from agriculture.

There were four main questions discussed at the workshop:

Q1. What do you consider the main issues on the EU level related to drinking water resource protection against diffuse pollution of nitrates and pesticides from agriculture in the EU?

Q2. What do you consider the main barriers in solving the issues in the EU policies related to drinking water resource protection against diffuse pollution of nitrates and pesticides from agriculture in the EU?

Q3. In your opinion, how is the relationship between science and policy in the EU policies reflected in EU legislation and its implementation, with particular attention to drinking water resource protection against diffuse pollution of nitrates and pesticides from agriculture?

Q4. In your opinion, how can the system at the EU level be improved, i.e., what are possible solutions to enhance role of integrated scientific support for EU policy and its implementation related to drinking water resource protection against diffuse pollution of nitrates and pesticides from agriculture?

Each question was hosted by a table host, who led the discussions. There was a 15 min round per question. Altogether, 9 participants from EU-level actor organizations and 1 participant representing the H2020 project were divided into two groups (Table 1). At the beginning of each round, the table hosts briefly shared vital insights from the prior conversation, so the new group could link and build on ideas from previous rounds if they wanted to. After 10–13 min, the table hosts started collecting ideas and forming short summaries of opinions of the groups and wrote them on sticky notes, used later in the main discussion. After the break, the main discussion followed in which the table hosts presented the main opinions, which were formed into final statements by all participants.

Invitations to participate in the interview were sent in three rounds to 31 identified individuals representing top EU-level actors (European Commission [EC], European Parliament, councils, associations, federations, companies, and partnerships) with knowledge in the field of drinking water and agriculture. Altogether, the response to our inquiries was five interviews with EC and some other representatives (Table 1). The primary objective of the interviews was to gather opinions of actors unable to attend the workshop.

The interviews were performed via telephone calls with a duration of about 20 min. Interview questions were the same as the workshop questions. We decided to use the same questions to gain a more in-depth insight on the topic of issues and barriers around providing integrated scientific support for EU policy.

Table 1. Representative EU-level actor organizations attending the workshop and interviews.

EU-level Actor Organizations that Participated in the Study	
Workshop	**Interviews**
European Fertilizer Blenders Association (EFBA), Research and Advice in Agriculture and Horticulture (Inagro), European Centre of Employers and Enterprises Providing Public Services and Services of General Interest (CEEP), European Federation of Bottled Water (EFBW), FERTINNOWA H2020 project, European Federation for Water Services (EurEau), Aqua Publica Europea (APE), European Energy Forum (BDEW), European Water Partnership (EWP), European Forum for Agricultural and Rural Advisory Services (EUFRAS)	European Innovation Partnership for Agriculture (EIP AGRI) focus group (adviser), European Commission Directorate-General for Research and Innovation, European Commission Directorate-General for Agriculture and Rural Development, Independent Flemish Research Organization (VITO) WATERPROTECT project leader, Wageningen University and Research (WUR) FAIRWAY project leader

2.3. Limitations and Uncertainties

The main limitations of the workshop and interviews are related to the relatively few EU-level actors that were involved in the study. For the interviews we identified 31 individuals and for the workshop 29 EU-level organizations from 3 sectors. These included 9 from the agricultural sector, 11 from the water sector and 9 EC organizations (Directorate-General (DG), EIP). The response rate of the organizations that joined the workshop was 34%, which was an 18% higher participation rate than was received with the interviews. The difference is likely because we invited organizations to the workshop, not specific individuals, so organizations had a broader spectrum of representatives to choose from. In the case of the interviews, it was challenging to get in touch with the invited representatives, as they did not respond to e-mails or phone calls, not even after three attempts. Because answers to specific questions were collected from specific individuals representing science and policy, and due to the limited sample size, it is possible that the answers reported by workshop and interview participants reveal a limited representation of the average opinion of EU-level actors.

3. Results and Discussion

3.1. Desk Study

3.1.1. Agriculture and Water Quality in the EU

Agriculture accounts for almost half of the total EU land area and is a primary source of diffuse pollution of nutrients and pesticides significantly affecting most of the EU river basins [12,13]. Rapid changes in farming systems in the post-war decades allowed an increase in agricultural productivity and caused considerable impacts (physical and chemical) on freshwater resources [1,13–15]. The focus on groundwater mainly concerns its use as drinking water as about 75% of EU inhabitants depend on groundwater for their water supply [16].

The WFD requires that primary directives and other policies tackling point sources and diffuse pollution at the source are first implemented fully (i.e., ND, GWD, DSUP, Urban Waste Water Treatment Directive, Industrial Emissions Directive) before complementary policies and additional measures are used [17,18]. Data show that within 63% of the river basin districts reported, implementation of the ND is not enough to tackle diffuse pollution at the level needed to secure WFD objectives [19]. Implementation of the ND in 1991 decreased nutrient surpluses and improved groundwater quality by 16% by 2008 [20]. However, according to communication from the Commission to the European Parliament and the Council, diffuse pollution of nitrate significantly affects 90% of river basin districts, 50% of surface water bodies and 33% of groundwater bodies across the EU [18,19,21]. The nitrate target of 50 mg/L is still exceeded in areas of shallow and sandy groundwater and intensive agriculture [22].

Despite substantial progress in reducing the consumption of mineral fertilizer, there are other important sources of fertilizers such as manure and other organic sources that must also be reduced.

There are still many gaps in the basic measures that have been put in place by member states to address agricultural pressures, including a lack of measures to control phosphate and nitrate emissions outside nitrate vulnerable zones established under the ND [19] and within and outside of the drinking water protection areas. Additional loopholes are that member states have the opportunity to apply for derogation within ND (e.g., a manure application rate that contains more than 170 kg nitrogen (N) per ha under certain conditions) or in the interpretation of the nitrogen application limit (e.g., adding gaseous losses of nitrogen on top of the general limit) [23]. These gaps leave us with the belief that, due to political reasons, individual member states or regions are avoiding or postponing actions that would lead to solving the water quality problem. On the other hand, while national or EU funding can enhance the role of science and research projects in relation to policy, they rarely contribute to actual capacity building in the legislative sector and have limited influence on problem-solving or key stakeholders. In addition to strong professional organizations inhibiting structural changes in local areas, legislators rarely provide additional money to implement measures from River Basin Management Plans (RBMPs) as they rely on money from agricultural funds to tackle pollution from agricultural sources [12,14,16,22].

Supplementary measures reported in agriculture are mainly voluntary, including advice schemes and agri-environmental measures of the Common Agriculture Policy (CAP), such as farm extensification and organic agriculture. Research and restoration efforts have been developed to recover ecosystem functions and services [19]. Several EU member states have recognized that losses of N from agriculture have been reduced significantly, especially in nitrate vulnerable zones, but further reductions are required to comply with the EU WFD [22,24–27]. As a further general reduction in nutrients may affect farm economics, a paradigm change is therefore proposed by Danish scientists, who propose severe restrictions on the application of fertilizers on land vulnerable to leaching of nitrates to the aquatic environment and a potential easing of restrictions in other areas [15,26]. A lesson learned in Denmark is that general policies can be usefully applied to control a widespread excessive application of N, but once this has been achieved, if further reductions are necessary, a switch to higher precision farming with targeted measures is required [26]. Introducing agri-environmental climate measures (AECMs) to policy can be fraught with difficulty in the form of delays and legal proceedings when the legal and regulatory complexity of adopting such measures at the national level to achieve site-specific environmental objectives is underestimated in a top-down political process [1].

On the other hand, there is growing acceptance among farmers of the environmental benefits of such policies. However, skepticism remains around the validity of specific measures, especially if their impacts are not supported by scientific evidence [28]. Science and policy should cooperate in checking the efficiency of AECMs with delivery, impact metrics, and appropriate standards for identifying trajectories associated with diffuse pollution transfer and ensuring that agri-environmental policies are given a fair and thorough evaluation and modified in the next Common Agricultural Policy cycle, 2021–2027 [24].

The EC Staff Working Document on the water–agriculture nexus [12] acknowledges the delicate balance between agriculture and water-related objectives defined in different directives (WFD, ND, DSUP, DWD) or Common Agricultural Policy (CAP) programs. The Working Document ascertains that less progress has been made than expected with respect to water quality improvements, and it shows political correctness when the EC offers to help member states to overcome this problem and support them in their quest to implement efficient measures. The approach focuses on (1) optimizing the effectiveness of the EU water and agriculture policies, (2) reviewing possibilities for supporting investments and (3) supporting knowledge and innovation transfer. Of course, more than just politically correct words are needed. The identification and implementation of efficient measures that are optimal for specific river basin spatial, climate and socioeconomic conditions is closely related to the active role of science in policy making and policies implementation [29].

An essential factor for successful implementation of voluntary agri-environmental measures for water quality improvement are the behavioral issues related to farmers' willingness to adopt science-based methods under the absence of strict regulatory control or without economically fair compensation. This fact indicates that a comprehensive understanding of the influences and extension tools that support farmers' management decisions is necessary, which can only be provided by the science and research sector [30].

Farmers' management decisions involve a compilation of unique factors including attitudes, motivations, socioeconomic circumstances, agricultural production contexts, policies and support, beliefs, pride, desire and goals, and not all of them have a rational or universal argument [31,32]. Farmers' long-term commitment to conservation measures is the result of evolution over time in which their values are "constantly modified and negotiated by social interactions" [32]. Farmers are keen to weigh the feasibility, effectiveness, profitability, and advantages of recommended management practices. Policies should remain grounded in subsidy payments, as environmental beliefs motivate only a minority of farmers [32]. However, sufficient support in terms of technical knowledge provided by agricultural extension services in the form of information sharing networks among farmers, participatory group learning, or personal communication is critical, as it increases the likelihood of conservation measures being adopted [30,31,33]. To better estimate the level and rate of adoption among farmer populations with a diverse range of practices, an adoption and diffusion outcome prediction tool was developed [34] that is able to define relative advantages of a practice, people's perceptions, ease and speed of learning about the practice, and potential adopters [34].

The authors above showed that barriers to enhancing the role of science in policy making and implementation already exist at the member state/region level or even at the individual farmer level. The majority of barriers are connected to political decisions or, better, indecisions made in revealing the ambivalent nature of daily politics in serving public needs and when taking into account sectoral socioeconomic conditions [35]. Often, science-based methods require changes in legislative documents that policy is not willing to open and update due to possible public debate and confrontations or because they require allocation of funds from other sectors [35]. This fact narrows our research question as one would ask which level of agricultural policy (EU, national, regional, local or farm level) is the most appropriate for science to enter the process in order to enhance its role and to have an actual impact on agricultural management and the improvement of drinking water quality. The literature shows that the presence of science is required at all levels with a particular emphasis on farmers, as they are the key stakeholders.

3.1.2. Evidence-Based Policy Making in the EU

Evidence-based policy is a concept that was developed in the 1970s, which received renewed strength in the late 1990s [36]. These kinds of policies can be described as science-based programs for action that guide decision making in service to the practical achievement of clearly designated outcomes [37]. Evidence-informed decision-making processes, relying on the transparent use of sound evidence and appropriate consultation, are seen as contributing to balanced policies and legitimate governance. However, the processing of expert knowledge is problematic and highly variable across policy making organizations. The potential for a close linkage between "good information" and "good policy making" is routinely undermined by two essential mechanisms—political and organizational—concerning the legitimacy of policy making processes as well as public trust in decision makers [36]. This fact leads to four approaches that describe the role of science in relation to policy: (1) knowledge shaping policy, (2) politics shaping knowledge, (3) co-production, and (4) autonomous spheres [38].

The Lisbon Strategy, adopted by the EU member states in 2000, moved the role of science into a central position for the development of a European knowledge-based economy and society and increased the involvement of scientists in science policy making (co-production) [39]. After that, European science organizations and eminent scientists initiated a common movement that led to the creation of the European Research Council (ERC) to support basic research of the highest quality. The ERC is supported by different financial instruments such as the European Union's Research and Innovation funding program (e.g., Horizon 2020).

In 2007, the European Commission identified the connectivity of the research area with research policy and society in Europe as an important EU challenge [40]. In 2008, the EC Directorate General for Research and Innovation (DG RTD) issued a report with specific recommendations: (1) DG RTD has a pivotal role to play in ensuring that project results are disseminated across the European Commission and should ensure that supported project groups fully understand the importance of producing communication material that is useful, accessible and meaningful to policy makers; and, (2) project coordinators should be encouraged to put the usefulness of their scientific research findings in regards to policy at the forefront of their objectives and actively include partners from the world of policy making (EC) to ensure that the scope of the research responds to defined policy making priority areas [4].

After decades of intensive discussion on this topic, it was demonstrated that decision makers' behavior in the processing of information varies across policy areas. Differences in vocabulary, a lack of understanding of the counterpart's mode of operation, and a lack of interaction between decision makers and researchers may result in information that does not meet the needs of society (forming "relevance gaps") and is thus less useful, although scientifically valid and reliable [7,36,41–43]. Slow responses in funding or disinterest among policy makers in implementing new scientific developments in practice may paralyze scientific endeavors and slow down water quality improvements [44]. The practice of bringing research findings into the policy and practice arenas by publishing in peer-reviewed journals is deeply embedded within the system of science and its incentive structures.

Though often relevant for practitioners, professional scientific findings are rarely presented in a language or form that can be easily used and applied by decision makers, who primarily use governmental and internal institutional information sources [7,35,45], or by farmers, who rely on governmental institutions, extension services or the media. In the media, especially social media, skepticism is often present in regards to scientific results. They are presented as conspiracy theories regardless of whether they confirm or reject common public beliefs initiated by politics, which subsequently has an influence on groups and individuals. Policy makers need to be open-minded, have a broad view of the world and society, and take scientific results seriously, as they canvas are the ones with the tools to design solutions for economic, environmental, social and cultural problems [45,46]. A study by Radin [35] showed that scientists often have to defend their work as their methodologies or results are misinterpreted by policy makers, politicians or influencing groups. To avoid an ambivalent attitude by society, scientists argue that their work needs professional control and deserves deference [35]. The above studies show the complexity of science's role in the process of policy making and its actual implementation, which can work only if all parties involved in the process are willing to work together [46] and take advantage of knowledge sharing through the exchange of new knowledge and skills [47].

The European Union made a substantial investment in research and innovation in the past decades through its Framework Programmes for Research and Technological Development, including the current program, Horizon 2020 (2014–2020), and its subsequent program, Horizon Europe (2021–2027), in order to respond to and provide substantial scientific evidence for the numerous policies at the union level [48]. At the same time, EC DGs opened calls for tenders (service contracts) with a particular focus on underpinning policy implementation, monitoring, and evaluation. Service contracts are (a) relevant, as they address policy makers' key questions (very specific); (b) credible, as they are scientifically sound and authoritative (at least good enough); (c) legitimate, as they are developed through processes that can be trusted (competent consortium); and (d) timely, as they deliver reports on time to inform the decision-making process (timeliness is a key advantage compared to research and innovation action (RIA) projects). Improvements are observed as exploitation and dissemination activities are under contractual grant agreement obligation for researchers participating in EU projects and are evident in service contracts [48].

Science–policy dialogues in EU projects or service contracts have many forms [9,48,49]: (1) Policy makers are invited to meetings (e.g., EIP focus groups); (2) conferences or events are organized by projects or the EC; (3) project participants are members of EU or national scientific advisory committees; (4) ministries or other national regulatory bodies or policy makers are directly involved as beneficiaries in projects; (5) projects seek input from regulatory stakeholders through surveys and inform them regularly through policy briefs; (6) representatives from policy making bodies participate in (scientific) advisory boards of projects; (7) projects involve professional scientific societies, stakeholder associations or civil society organizations; (8) the EC assists projects to ensure and facilitate the uptake of scientific results into policies by providing responses to members of the European Parliament, who often enquire about outcomes of projects; and (9) open access publications and data are available so that stakeholders, including policy makers, can get the maximum benefit from EU-funded projects and scientific research.

The organizational structure of scientific support of the EC consists of several levels. The highest is the Directorate General (DG), of which there are 31 in operation. The DGs are closely connected with the Joint Research Centre and its ten science work areas. Aimed at bringing together all relevant actors at the EU, national and regional levels, the European Innovation Partnership (EIP) works with five challenge-driven partnerships formed under the EU Horizon 2020 Innovation. The partnerships are supported by steering groups that create different task forces and work platforms. For our study, the most critical DGs are Agriculture, Environment, and Research and Innovation. The importance of the commission's DGs in regard to the redistribution of money to specific scientific fields is shown in the numerous interest groups (nongovernmental organizations (NGOs), private and public companies, multinational corporations), including the other EU bodies and the member-state governments, that are all lobbying the commission for their desired outcomes [50].

Since the establishment of the EC, there have been 180 European research projects with the word "water" in the name and 75 with the term "agri" under different funding systems (Framework funding, Horizon 2020, European Research Centre, etc.) [51]. Moreover, intergovernmental joint programming initiatives are formed to tackle major societal challenges unable to be addressed by individual countries. These are contributions to the development of the European Research Area. In 2010, the joint programming initiative (JPI) "Water challenges for a changing world" was formed. It is tackling the challenge of achieving sustainable water systems for a sustainable economy in Europe and abroad [52]. Knowledge and innovation communities bring together higher education, research, business, and entrepreneurship in order to produce practical innovations and innovation models that can inspire others to follow. They are created by the European Institute of Innovation and Technology (EIT), founded in 2008 [52].

In order to protect the quality of drinking water, the European Union, along with its scientific support services, has developed and published an extensive set of directives, policies, guidelines, research projects, websites, and literature. The EC is monitoring the implementation of EU legislation in the member states through reporting and monitoring. Based on their internal monitoring, the member states submit information and data to the EC. After these national reports are analyzed, the findings are presented in various ways (implementation reports, indicators and scoreboards, other publications). The European Commission often works in collaboration with Eurostat, the Joint Research Centre or other agencies, depending on the legislation concerned. Environmental monitoring usually leads to data collection and reporting (Figure 1).

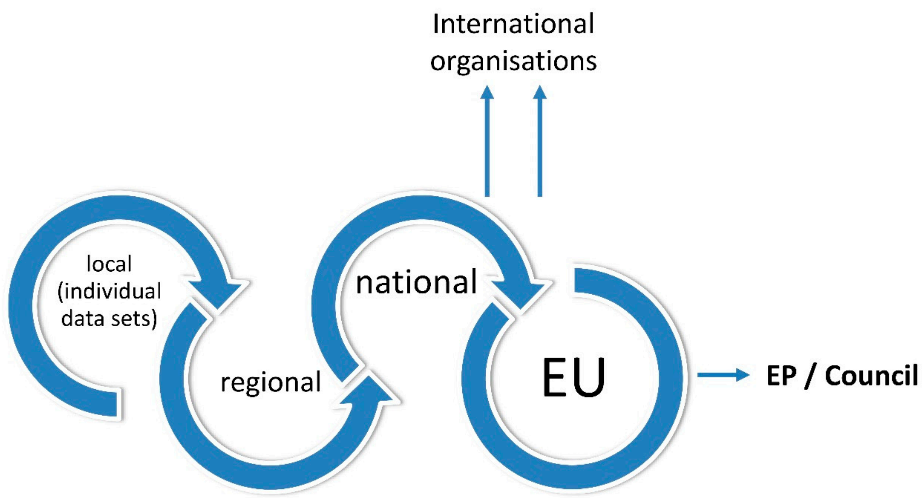

Figure 1. A data flow process for the implementation of environmental legislation in the EU. Adapted by [53].

One would think that science has many opportunities to enhance its role in transferring scientific results to the policy making and policy implementation process, with the goal of reducing the agricultural impact on drinking water quality. However, a report of the European Parliament (EP) and the European University Institute on evidence and analysis in EU policy making concluded that institutional systems have an inbuilt tendency to resist change [8,35,45]. One of the key problems of evidence-based policy making is bureaucratic inertia, which limits the potential to accept new developments and ideas [8,54]. Public administrators leading the policy making process can also influence outcomes by choosing among different theories or methods and by their attention to marginal or incremental facts and values [54,55]. Therefore, the enlightened determination of which facts are important and should be directed to the attention of analysts is required in order for policy makers to make relevant choices that broaden the range of policy options [56]. Studies show that government decision makers tend to use science and research project results somewhat more indirectly, as a source of ideas, information, and orientation [54,56]. Science has a chance to enhance its role and turn the odds of influencing the policy process in their favor by employing three overarching strategies consistently over time: developing in-depth knowledge, building networks, and engaging in active participation for an extended period [57].

The literature gives many examples of how water resource management is inherently political. It defends the dominant stance of water professionals in that "politics" should be removed, as politics compromises the accountability, transparency, and legitimacy of decisions made [35,58–60]. However, WFD brought new challenges to politics at jurisdictional scales of operation in the form of hydrological scales prescribed for water management planning. It was observed that relevant stakeholders are increasingly working across scales to advance their interests in different ways; they are redefining and reconstituting the function and significance of scales and creating new scalar hybrids at the interface between hydrological and jurisdictional domains [61]. The extent to which specific measures can be implemented (uptake, blockade) is dependent on complex politics and powerful coalitions across multilevel governance systems and scales of interest (NGOs, businesses, corporations) with an emphasis on higher governance levels [62]. The politics that mediate the use of environmental science assessments as the basis of resource management policy have an opportunity to identify the subjective ways in which scientific assessments could be interpreted so that they can be used by state water resource agencies to underpin water allocation decisions that follow their interests [59].

Scientists, as experts for certain measures, may take a role in supporting or blocking coalitions, but their evaluations of water system sustainability and security are likely to be met with competing claims based on different values and expertise [62]. The importance of the public's or voters' opinions of politicians should not be undermined, as we can observe a daily battle for the truth to prevail between environmental and industrial groups [60] and between rigid ideologies generating contentious opinion exchanges and lenient liberal ideologies encouraging long-term solutions [35]. A recent study suggested that the tendency of political leaders to address environmental problems is primarily influenced by their aspiration to confirm an individual political status or conform to group norms. Younger politicians show a greater tendency to address environmental problems [63]. The role of science in relation to politics is inevitably subordinate as the political logic of the cost-benefit economic analysis approach usually prevails over the logic of science-based rules of reasoning [35]. This further narrows the research question, as one could ask whether it is necessary for science to enter the political decision-making process directly at the top of the system, where research work would have a significant impact, but could also be misused to achieve political goals.

3.1.3. EU WFD: Where Water Policy and Water Science Meet

The WFD is probably the most essential water-related EU directive concerning the demand for knowledge support. This has been demonstrated in its attempt to work towards a tangible water policy and research objective for achieving good water status in an integrated and sustainable manner by 2015 [10,17,64]. The knowledge support is facilitated by a participatory River Basin Management Plan (RBMP) system and implemented through water quality and ecosystem assessments, extensive monitoring, and inter- or multidisciplinary participatory and pragmatic research [65,66]. The WFD represents a shift in approach from the traditional unilateral focus on sources of pollution and disturbance to a new combined approach. It also requires the collaborative production of new scientific knowledge that is effectively adopted and communicated between policy makers, policy implementers, and the research base informing policy work [66,67].

Within the WFD Common Implementation Strategy (CIS), operational since 2001, nonbinding guidance documents on sharing good practices have been recognized for presenting and communicating results of research and demonstration projects in a readily usable form to policy makers at regional and national levels to show how to integrate the latest research developments into legislation [3,65]. The WFD has been a significant force in raising awareness of the need to restore Europe's rivers, but its application during the first management cycle was limited [68,69]. The deadline for all rivers to be in a good ecological state passed due to a lack of effective policies and an inappropriate timescale for the resilience of water systems, especially groundwater systems [14,17]. To tackle this problem, the WFD now requires member states to design and implement cost-effective programs or measures to achieve the "good status" objective by 2027 at the latest [14,21].

At the same time, policy- and decision-making arenas will require the willingness and confidence of the water sector to engage with actors from other sectors. This is essential in making progress on water challenges [9] and for positioning the role of science as an equal partner in policy making and implementation [3,7,70]. A lack of science integration at the national/regional and river basin level can be seen in the results of recent studies that finished after the first cycle in 2015 [9,17,68,71,72]. This is at least partly due to a lack of appropriate communication about the relevant research results that would be of use to policy-relevant strategies [7,70,73]. Research or policy communities themselves encompass multiple smaller expertise areas or subsectors (e.g., surface water, groundwater, irrigation, energy, drinking water, wastewater, transport, environment protection, land use planning, tourism) grouped around separate disciplines with their own practices and language, which hampers integration and weakens communication [64,74]. This indicates a multiplicity of challenges related to spatial scales and the multiple levels of governance that are central to water resource management [75]. The WFD, a complex directive, is subject to many uncertainties related to implementing institutions in member states. Surprisingly, it has been argued that they are not systematically addressed in the directive or CIS guidance document. It is further argued that interest groups and the general public participating in RBMP implementation can manage and reduce uncertainties [76,77] if authorities group participants by scope, communicate with the public, work on capacity building, define timeliness, finance participation, and institutionalize stakeholder participation by creating organizational cultures that can facilitate processes [77,78]. Directives, legislation, and management programs are often implemented cyclically (e.g., RBMP on a six-year cycle, ND on a four-year cycle) and regularly reviewed, which provides windows of opportunity for participating actors to draw together new evidence and approaches for measure implementation [17,79].

The Science-Policy Interface (SPI) for water activity was launched in 2010, led by DG RTD and the French national agency for water and aquatic ecosystems (ONEMA). It provides an interactive forum to ensure a cooperative interface between water researchers and policy makers, managers and stakeholders at both the EU and national level [3,7,69,80,81]. Strategic use of the SPI, with specific policy milestones and effective mechanisms, should facilitate the development of innovative solutions to achieve policy goals and to create the conditions necessary for transformative change towards an exchange platform enabling both scientists and policy makers to discuss similar research and policy agendas [3,71]. SPI activities (e.g., Water Information System for Europe, WISE) also demonstrate that although networks/lobbying organizations (IAH, EGS, IGRAC, EUREAU, Eurometaux, EEB, etc.) already exist, they need stronger, even permanent, involvement [80].

The studied literature shows that the complex and dynamic nature of water governance in the EU requires flexible and reactive water policy networks that include network openness, business-like behavior, less domination by professional engineering groups, and diversity of knowledge and values [75,77,82]. One could ask if science is still needed in the process of setting RBMPs and whether public participants with knowledge of local conditions and biased groups with wide ranges of partial interest can be good substitutes to replace scientists. The literature confirms that the role of scientific knowledge should be emphasized in the process to better understand complex and dynamic hydrological, agronomic, natural and socioeconomic systems and processes as well as to evaluate the soundness of potential solutions to water quality problems [77].

3.2. Results of the Workshop and Interviews

3.2.1. Main Issues (Q1)

The participants were asked about the main issues on the EU level related to drinking water resource protection against diffuse pollution of nitrates and pesticides from agriculture in the EU. The following issues were highlighted by the participants in the workshop (Figure 2):

- Lack of knowledge about agricultural impacts on water quality.
- Harmonization of legislation needed at the EU level, with water protection currently a very local issue.
- Lack of coherence between policies.
- Synergies and trade-offs between goals and pathways of pollution.
- Lack of balance between targets and objectives of EU policies.
- A time lag between taking measures and changes in water quality.
- Fragmented and not easily available data.
- Financial questions about available budgets and allocation of the costs.

Interviewees highlighted two main issues related to drinking water resource protection in the EU: (i) There is a general lack of knowledge about the relationship between agriculture and water quality, which calls for a stronger contribution from science, and (ii) drinking water protection is a local issue with local characteristics. They also indicated that a lack of communication between water authorities, people responsible for RBMPs, the farming community, and agricultural departments is an issue. All agreed that more bottom-up, inclusive processes should be stimulated in the field of water resource protection.

One of the issues concerning nitrates is that the ND does not specify an objective by which specific results have to be achieved, unlike the WFD. There are widely differing interpretations of what role the ND should play in the WFD in addressing nitrate pollution issues. Participants identified significant variations in how member states have addressed this issue. The predominant approach so far has been that member states take a minimum approach to implementation of the ND (only measures that are mandatory for farmers) and that they include voluntary measures as part of WFD implementation, often funded through the Rural Development Program (RDP). Another issue related to nitrate pollution is the cost of investments needed for compliance. For example, for small farmers, it can be difficult to comply with manure storage requirements. Also, as the storage norms have already been enforced for some time now, EU funds can no longer support investments for compliance.

The issue of nitrate pollution from overstocking was mentioned in the workshop, such as in regions in Germany, Flanders, the Netherlands, Brittany, and Catalonia. A significant part of the nitrate pollution comes from farms that do not have land and do not fall under the CAP. In these regions and in regions with intensively managed cropping systems, such as vegetables in Andalucía and the Netherlands, there is frequently an overuse of manure and mineral fertilizers leading to nitrate leaching into groundwater and surface water. Very few member states have set out a comprehensive approach to reducing nitrate leaching in order to meet the target goals of the WFD.

Figure 2. Key points for Questions 1, 2, 3 and 4 on the role of science in EU policy making and implementation related to drinking water resource protection against diffuse pollution of nitrates and pesticides from agriculture in the EU.

The main issue of pesticides on the EU level is the implementation of the sustainable use of pesticides directive (SUPD). Participants indicated that implementation of the SUPD had been delayed in member states; and, reports on the implementation have been delayed for two years. This report should address issues of pesticides in all areas, not just drinking water. There is a definite increase in pesticide use, so the adoption of integrated pest management across Europe is urgent. Participants stated that the main reason for the delay of the report is political and the report is no longer on the priority list of the European Commission.

The participants of the workshop agreed that there is already much legislation on the protection of drinking water and there is no need to change legislation. It just needs to be implemented well by member states. It was also indicated that the EU level of implementation of legislation is political, and not a science issue. The process of water resource protection is mainly limited by politicians who do not want to impose costs on farmers unduly.

3.2.2. Main barriers (Q2)

Sociocultural factors or differences between member state countries and regions in Europe were mentioned as primary barriers to successful implementation of EU water policies. Problems with translation and transposition of EU policies on the local level were also highlighted. The topic of a lack of funding for implementing measures was omnipresent. The main barriers are the following (Figure 2):

- Lack of political will to impose costs on farmers, and limited financial means needed to apply specific measures.
- Lack of awareness of the required actions by farmers to achieve water quality targets and a need for capacity in advisory services.
- Lack of communication or synchronization of languages between scientists and policy makers
- Site-specific aspects in taking effective measures, e.g., differences between member states and regions.
- A time lag between taking measures and subsequent changes in water quality.
- Not enough farmers involved.

There were three main barriers mentioned by the interviewees. First, the political priority is important. There is a lack of political will to impose policies and costs on farmers. It is also costly to provide good advisory services and control bodies to check what is happening or should be happening on farms. The second barrier was a need for capacity in advisory services on the implementation of measures and in regulatory bodies on monitoring measures and water quality. There should be a willingness to address these issues. More is needed besides guidelines, i.e., engagement and (auto) control of local actors. The third highlighted barrier is the lack of communication or synchronization between different instruments. The Common Agriculture Policy planning cycle is different from the WFD planning cycle. It happens that when a national RDP as part of CAP is prepared, River Basin Management Plans as part of WFD are not yet approved, etc.

Participants also highlighted that diffuse pollution is much more difficult to manage than point source pollution because it is complicated to control thousands of farmers who take individual actions. Sometimes, the lack of knowledge on good agricultural and environmental conditions in relation to cross-compliance of farming practices and EU policies as well as economic reasons is a significant barrier too. A farmer's knowledge on the objectives of EU policies, such as the need to decrease nitrate leaching to improve drinking water quality, often varies between member states and depends on the farmer's age and level of attained education. In addition, manure and fertilizers are often cheap, and from a strictly economic perspective, farmers tend to apply more than sufficient amounts of nitrogen to avoid the risk of low yields in years of optimal conditions. In regions with intensive livestock, manure is often seen as waste and is applied to soils only in the proximity of the livestock farm, because transporting to other regions is too expensive. In the Netherlands, the excess manure of livestock farms (mainly pig farms) has a negative price, meaning that crop farmers receive money for accepting manure from pig farmers. Although manure application is strictly regulated by both nitrogen and phosphorus standards in the Netherlands, the negative manure price (an additional income for crop farmers) does not stimulate innovations to improve the nutrient management and increase the efficient nutrient use of manure.

On the other hand, participants also highlighted good, positive examples in Europe. In Scotland, there is a targeted approach for identifying catchments of higher priority (for drinking water or high-value fisheries). They put most of their resources into these areas, map all of the problems and then go back repeatedly to farmers to give them targeted advice. They also provide economic support to resolve the issues. If the problems are not resolved after the third time, fines are issued. This example stands out as a clear, targeted strategy for delivering results in a given geographic area. However, if this were not a political priority and supported by scientific knowledge, all these efforts would never be made.

3.2.3. How the Relationship between Science and Policy is Reflected in EU Policy (Q3)

First, the topic of public participation seen as part of democracy's impact on science was highlighted in the workshop in relation to the question on how the relationship between science and policy is reflected in EU legislation. Participants of the workshop agreed that public participation could be dangerous because if something is scientifically correct, we cannot discuss it and change it to suit the popular sense (populism, nationalism, corporatism). Participants debated over the fact that scientific work should be done independently because it is a methodological process (while policy or, more precisely, politics is a democratic process). The public could be involved in determining prioritizing issues for investigation and the broader topics that should be included within the scientific process (i.e., effects of sociologic factors). Once the research is finished, information should be presented to the public so that interested parties are made aware of the current status of the topic, and then the information can be used in democratic policy making processes (Figure 2).

Second, some interviewees pointed out that the formal relationship between science and policy in the EU directives is to be defined in the national transposition, but the policy text does not specify how this should be done. This is a decision of the member states. There is a clear link between science and policy in, for example, the ND and the WFD. The nitrate action plan, to be revised every four years, should be based on monitoring and the results achieved from the previous plan. If there is a feedback mechanism, we can understand what a previous plan has accomplished and can design our next set of measures based on that. In addition, the WFD has articles on different classifications and the need for a plan with the programs of measures that will be addressed. There is a link established between understanding the current situation, knowing what has been done before, and knowing what the end goal is, and then taking the most cost-effective measures to achieve it. It is clear that science and research should take a central role in this process.

One of the workshop participants mentioned an example from Ireland, an agricultural catchment program, where scientists tried many different measures in different catchments to address diffuse pollution. The best measures were then transferred to the ND action program policy making process and included in the RDP to be funded. By demonstrating the measures to the farmers, they learn how they work, which helps to get the measures incorporated into national program. Behind the agricultural catchment program in Ireland was the political will to address the issue. The link is established, and there is a good working relationship between the environmental and agricultural authorities, the agricultural advisory services and the scientists. This often does not work in many member states because there is often no agreement between the agricultural and environmental sides on what should be done.

Third, all interviewees and workshop participants pointed out that there should be more opportunities to enhance the role of scientific expertise in policy making. The entry point for the science/research community, funded by the Horizon 2020 program's call for a decision-making procedure in the EU, is presented in Figure 3. Interviewees from DGs and certain workshop participants who were previously involved in preparing EU legislation stated that the policy cycle is often so fast that there is not enough time to consider the most valuable independent scientific advice, but rather the most available. Moreover, it was expressed that in many EU research projects, dissemination tended to be very formal and bureaucratic, not designed to maximize impact. Some workshop participants perceived that the way the commission uses the results of these projects is unclear. One of the most relevant factors is low resource availability at the European Commission. Where the highest level of technical knowledge and assessment is located within European institutions, there is limited staff available to deal with all EC essential tasks, so less necessary ones like science-to-policy interaction are often not given priority. Some participants think that the CORDIS web platform used by the commission is not always helpful; some stated that it appears that while the EU is funding projects, they are not using the information they provide. An idea was proposed to set up a functional system of disseminating summaries, by topic, to civil servants who could use the information.

Fourth, participants of the workshop pointed out the importance of numerous ongoing and available service contracts for DG Environment, e.g., implementation of the Nitrates Directive. Studies include assessments of nitrate action plans (with measures) of member states and general studies on aspects of nitrate leaching. The commission uses the results of these studies in discussions with member states. This means that it is clear how the role of science supports the implementation of the Nitrates Directive. The commission has similar service contracts for other environmental directives. So, in general, the commission uses scientific information in its policies from specific service contracts. However, it is doubtful whether the member states and farmers use this information.

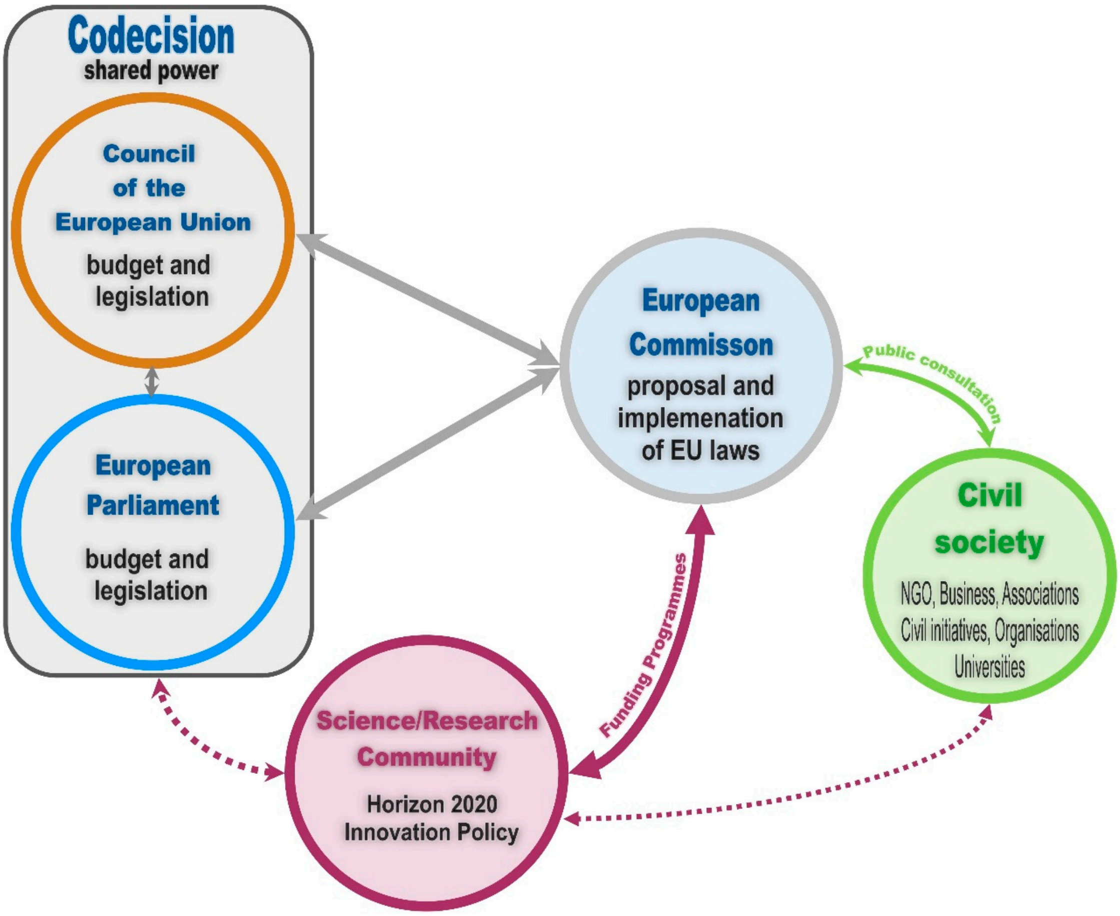

Figure 3. The entry point for the science/research community funded by the Horizon 2020 program's call for a decision making-procedure of the EU.

3.2.4. Improvements and Possible Solutions for Enhancing the Role of Integrated Scientific Support in EU Policy Decision Making (Q4)

The main debate at the workshop regarding solutions for improvement highlighted the need for the use of language that is easy for policy makers to understand and the need for physical meetings with project participants and stakeholders (Figure 2). Interviewees agreed that system improvements and possible solutions for enhancing the role of scientific support for EU policy making are an issue of national implementation.

The reform of CAP (seven-year cycles), constantly under negotiation, can enhance the role of science. For example, one proposed improvement is to make sure that there are clearly defined indicators in the monitoring and evaluation of CAP-supported efforts targeting reduced water pollution. Article VII of the WFD requires measures to be put in place at the catchment level so that the need for water companies to reduce their pollution will decrease. This measure should be reflected in agricultural legislation or in RDP to make sure that the costs are picked up by the CAP budget, farmers or consumers, and not by drinking water providers. The WFD will be reviewed in 2019, which will explicitly provide an opportunity to enhance the role of science in policy making. One of the interviewees proposed that this process could set a new attitude for policy makers and administrators regarding the current status, needs or upcoming changes, due to technological, practical or environmental changes in all connected sectors.

Workshop participants recalled that policy is now often based on indicators or data that are sometimes inconsistent, even outdated. All workshop participants agreed that with the digital revolution, with machine learning and data mining, we could and should have a real-time picture of what is happening (for example, with water quality in Europe). They added that many of the current instruments and mechanisms need to adapt and evolve. We can no longer implement a certain measure unchanged for six years. Instead, we should be monitoring and adapting in real time in order to provide more value for the public money spent. The entire relationship between data, information and decision making needs to change.

One of the proposed solutions from the participants was that the EU, as well as local actors, would need to equip themselves to make use of these new technologies, for example, to use data platforms and data mining. It was recommended to use these technologies as well as information from other fields and departments as a “feedback loop”, where one does something, gets feedback, and can then make adjustments based on the feedback. The EU is now actively pushing for data reuse and open data. The same data can be used for different purposes. Participants agreed that there is a high demand for specific dissemination techniques for specific audiences and in local languages. Relevant scientific knowledge is, broadly speaking, mostly available, and it should be translated into information that farmers and stakeholders at the local level can use in practice.

Besides the service contracts mentioned in Question 3, participants proposed that civil servants of the commission should have regular involvement in projects, such as H2020 projects, so that they can obtain new knowledge over the course of the project. This could be done by giving civil servants a definite role in the project (for example, in presentations, workshops, interviews, etc.). Furthermore, some projects focus on “their business” regardless of whether the topic is on the political agenda of the EC or not, with the aim of “ticking boxes” to fulfil the grant agreement obligations. One trend to make this process easier for everyone is to establish project clusters, aimed at longer-term approaches/teams and the use of gatekeepers in the relationship/communication flows. An example of such a cluster is the Biorefine Europe cluster (https://www.biorefine.eu/about), which interconnects projects and people within the domain of bio-based resource recovery and strives to contribute to more sustainable resource management.

4. Synthesis

This research is unique because ten years after the EC DG RTD general report on the state of the dialogue between policy makers and the science community for maximizing the policy making impact of projects [4], there is again an examination of whether the role of science has changed in relation to policy and politics. Was there a shift towards a better mutual understanding in an established iterative process of knowledge and practice exchange within a policy for integrating scientific support for EU policy?

We argue that this study shows that the status quo observed [4] 10 years ago and declared as an unsatisfactory condition was overreached at the level of EU level policy making and that much more effort at the member state/region level is needed in the policy implementation phase, where politics plays an important role. In recent years, the EC has been strengthening communication with the science community through focus groups, partnerships, meetings and web portals. However, desk studies, workshops and interviews show that the EC, despite having a substantial research and innovation budget, is not making the most of the project results. The reason for this is due to the limited staff available to deal with all of the key tasks of the EC, so less mandatory ones like science-to-policy interaction are often neglected.

Workshop participants and interviewees were well informed about the legislation, structure and information paths and about the importance of lobbying in the EU system between the European Commission, European Parliament, EU Council, corporations, NGOs and different research associations. EU legislation gives member states quite an important role in implementing EU legislation and common policies at the local level. They have the freedom to decide on the processes for addressing the issues, ways of implementing solutions, and the role of science in WFD-promoted integrated policy making. While some participants argued that legislation at the EU level should be unified and that high-level cohesion should be reached at the level of member states, other participants defended the current premise that each member state, region or local community should have the opportunity to shape its variety of general EU legislation on water protection or agriculture. Only the common goals at the EU level agreed upon by all member states (WFD, ND, CAP, SDG) should be followed. Nevertheless, science plays a vital role in supporting both types of policy making.

The Nitrates Directive does not have a set date for when the targets have to be achieved, unlike the WFD. Very few member states or regions set an exact load reduction that needs to be achieved, although border conditions (water quality, nutrient mass balance) are known and confirmed by science. Implementation of the SUPD has been delayed in some member states. There is much legislation under the implementation that still has to be fully implemented by member states. Barriers to providing the conditions necessary for enhancing the role of science in EU policy making and implementation are often connected with the political will to reach target goals, scarce instruction on the legislation implementation process, and a lack of funding opportunities for science to be included in policy making and implementation. We argue that examples from individual member states (Ireland, Scotland) show that smart policy makers can, by enhancing the role of science in the policy making and implementation process, generate positive effects on establishing links between water and agriculture policy.

Reflecting on the role of science in light of the EU legislation and decision-making process opened a discussion about public participation as part of the "democratic" impact on science. Public discussions, popular political actions relying on public opinion, and corporate interests can cause the overlooking of or even the change of scientifically correct results to suit a particular group's agenda. Science as a methodological process should be done independently, while policy making is a democratic process. Research results should be made public and available for democratic policy making. A solution for improving this issue calls on scientists to use language that is understandable by policy makers and the wider public, while avoiding oversimplification and distortion of reality when reducing the complexity of the information. That is why we argue that the role of science should be differentiated from the role of public participation. Science should be seen as a mediator in the process of understanding complex and dynamic hydrological, agronomic, natural and socioeconomic systems and processes, as well as a tool for evaluating the soundness of potential solutions to water quality problems.

However, we could argue whether the political agenda of the EU, which informed this research project, and hence whether the political agenda promoted in this manuscript, is still fully up to date. The study shows a lack of progress in certain areas when it comes to improving the input provided by science. One could wonder to what extent this is the result of the political conditions that the EU and specifically the European Commission have been facing in recent years when it comes to technocratic decision making. We made an effort to carefully distinguish the informational input of science from democratic decision making, although we cannot be sure if all EU level actors, those included in this study and those not, fully appreciate this distinction. However, this is certainly one of the reasons for anti-EU sentiments, in particular on the radical left and right in the name of more accountable/Machiavellian rather than democratic decision making. These types of sentiments could be one of the reasons for more caution, and hence a lack of progress, at all European policy levels when it comes to implementing an agenda that may quickly be interpreted as technocratic or elitist.

This study shows that, according to the views of participants, relevant RIA EU research project results are taken up by the European Commission, Parliament or Council indirectly, as a source of ideas and information. Although the process is not straightforward, it may, over time, result in distinct impacts on policy formation. Results emanating from service contract studies for DGs are used to a much more significant degree and often literally. The commission uses the results of these studies in discussions with member states, showing that science has a clear role in supporting policy making and implementation of EU legislation. Such service contracts often have a limited scope and often address member state implementation of various directives rather than new science that is produced in RIA projects. However, many of the solutions that would enhanced the role of science in the case of agricultural impacts on drinking water quality have to be found by politicians at the national or regional level. WFD, ND, DWD and other directives give member state politicians the opportunity to prepare tailor-made measures in cooperation with science and with sufficient funding, which will contribute to clean surface and groundwater drinking water resources.

Based on our study results, we argue that establishing project clusters (science, policy, stakeholders, and citizens) for up-to-date policy challenges and stakeholder needs and with citizen involvement is a viable solution to enhance the role of science in the EU integrated policy making process. The aim is to establish longer-term relationships and communication flows between scientists and policy makers, which will contribute to achieving more sustainable management of ecosystem (water, food) services.

Author Contributions: Conceptualization, M.G. and M.P.; Methodology, M.P., M.G., S.L., S.B. and G.V.; Formal Analysis, Š.Ž. and M.G.; Investigation, Š.Ž., M.P., M.G., S.L., S.B. and G.V.; Data Curation, Š.Ž.; Writing—Original Draft Preparation, M.G.; Writing—Review and Editing, M.P., S.L., S.B. and G.V.; Visualization, Š.Ž.; Supervision, M.P. and G.V.; Project Administration, G.V.; Funding Acquisition, G.V.

Funding: This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 727984.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Hansen, B.; Thorling, L.; Schullehner, J.; Termansen, M.; Dalgaard, T. Groundwater nitrate response to sustainable nitrogen management. *Sci. Rep.* **2017**, *7*, 1–12. [CrossRef] [PubMed]
2. Anglade, J.; Billen, G.; Gamier, J.; Makridis, T.; Puech, T.; Tittel, C. Nitrogen soil surface balance of organic vs conventional cash crop farming in the Seine watershed. *Agric. Syst.* **2015**, *139*, 82–92. [CrossRef]
3. Quevauviller, P. Is IWRM achievable in practice? Attempts to break disciplinary and sectoral walls through a science-policy interfacing framework in the context of the EU Water Framework Directive. *Irrig. Drain. Syst.* **2010**, *24*, 177–189. [CrossRef]

4. EU. *Scientific Evidence for Policy Making*; Directorate-General for Research and Innovation, European Commission: Brussels, Belgium, 2008.
5. EU. *Communication from the Commission on the Precautionary Principle*; European Commission: Brussels, Belgium, 2000.
6. Quevauviller, P.; Balabanis, P.; Fragakis, C.; Weydert, M.; Oliver, M.; Kaschl, A.; Arnold, G.; Kroll, A.; Galbiati, L.; Zaldivar, J.M.; et al. Science-policy integration needs in support of the implementation of the EU Water Framework Directive. *Environ. Sci. Policy* **2005**, *8*, 203–211. [CrossRef]
7. Weichselgartner, J.; Kasperson, R. Barriers in the science-policy-practice interface: Toward a knowledge-action-system in global environmental change research. *Glob. Environ. Chang.* **2010**, *20*, 266–277. [CrossRef]
8. EUI. *EP-EUI Policy Roundtable Evidence and Analysis in EU Policy-Making—Concepts, Practice and Governance*; Global Governance Programme (GGP) of the Robert Schuman Centre for Advanced Studies (RSCAS), Parliamentary Research Service (EPRS) of the European Parliament, European University Institute: Brussels, Belgium, 2016.
9. De Loe, R.C.; Patterson, J.J. Rethinking water governance: Moving beyond water-centric perspectives in a connected and changing world. *Nat. Resour. J.* **2017**, *57*, 75–99.
10. Quevauviller, P.; Barceló, D.; Beniston, M.; Djordjevic, S.; Harding, R.J.; Iglesias, A.; Ludwig, R.; Navarra, A.; Navarro Ortega, A.; Mark, O.; et al. Integration of research advances in modelling and monitoring in support of WFD river basin management planning in the context of climate change. *Sci. Total Environ.* **2012**, *440* (Suppl. C), 167–177. [CrossRef]
11. Ormerod, S.J.; Ray, G.C. Connecting the shifting currents of aquatic science and policy. *Aquat. Conserv.* **2016**, *26*, 995–1004. [CrossRef]
12. EC. *Agriculture and Sustainable Water Management in the EU (SWD(2017)153/F1)—Commission Staff Working Document*; European Commission: Brussels, Belgium, 2017.
13. Stoate, C.; Báldi, A.; Beja, P.; Boatman, N.D.; Herzon, I.; van Doorn, A.; de Snoo, G.R.; Rakosy, L.; Ramwell, C. Ecological impacts of early 21st century agricultural change in Europe—A review. *J. Environ. Manag.* **2009**, *91*, 22–46. [CrossRef]
14. Vernier, F.; Leccia-Phelpin, O.; Lescot, J.M.; Minette, S.; Miralles, A.; Barberis, D.; Scordia, C.; Kuentz-Simonet, V.; Tonneau, J.P. Integrated modeling of agricultural scenarios (IMAS) to support pesticide action plans: The case of the Coulonge drinking water catchment area (SW France). *Environ. Sci. Pollut. Res.* **2017**, *24*, 6923–6950. [CrossRef]
15. Jacobsen, B.H.; Anker, H.T.; Baaner, L. Implementing the water framework directive in Denmark—Lessons on agricultural measures from a legal and regulatory perspective. *Land Use Policy* **2017**, *67* (Suppl. C), 98–106. [CrossRef]
16. EU. Groundwater as a Resource. Available online: http://ec.europa.eu/environment/water/water-framework/groundwater/resource.htm (accessed on 25 October 2018).
17. Flavio, H.M.; Ferreira, P.; Formigo, N.; Svendsen, J.C. Reconciling agriculture and stream restoration in Europe: A review relating to the EU Water Framework Directive. *Sci. Total Environ.* **2017**, *596* (Suppl. C), 378–395. [CrossRef] [PubMed]
18. WRc. *European Level Report: Key Descriptive Statistics on the Consideration of Water Issues in the Rural Development Programmes 2014–2020, UC12064.01*; WRc plc, European Commission: Brussels, Belgium, 2016.
19. EU. *The Water Framework Directive and the Floods Directive: Actions towards the 'Good Status' of EU Water and to Reduce Flood Risks*; European Commission: Brussels, Belgium, 2015.
20. Velthof, G.L.; Lesschen, J.P.; Webb, J.; Pietrzak, S.; Miatkowski, Z.; Pinto, M.; Kros, J.; Oenema, O. The impact of the Nitrates Directive on nitrogen emissions from agriculture in the EU-27 during 2000–2008. *Sci. Total Environ.* **2014**, *468* (Suppl. C), 1225–1233. [CrossRef] [PubMed]
21. Hérivaux, C.; Orban, P.; Brouyère, S. Is it worth protecting groundwater from diffuse pollution with agri-environmental schemes? A hydro-economic modeling approach. *J. Environ. Manag.* **2013**, *128* (Suppl. C), 62–74. [CrossRef]
22. Van Grinsven, H.J.M.; Tiktak, A.; Rougoor, C.W. Evaluation of the Dutch implementation of the Nitrates directive, the water framework directive and the national emission ceilings directive. *Njas-Wagening. J. Life Sci.* **2016**, *78* (Suppl. C), 69–84. [CrossRef]

23. Van der Straeten, B.; Buysse, J.; Nolte, S.; Lauwers, L.; Claeys, D.; Van Huylenbroeck, G. The effect of EU derogation strategies on the compliance costs of the nitrate directive. *Sci. Total Environ.* **2012**, *421* (Suppl. C), 94–101. [CrossRef] [PubMed]
24. Wall, D.P.; Murphy, P.N.C.; Melland, A.R.; Mechan, S.; Shine, O.; Buckley, C.; Mellander, P.E.; Shortle, G.; Jordan, P. Evaluating nutrient source regulations at different scales in five agricultural catchments. *Environ. Sci. Policy* **2012**, *24* (Suppl. C), 34–43. [CrossRef]
25. Wall, D.; Jordan, P.; Melland, A.R.; Mellander, P.E.; Buckley, C.; Reaney, S.M.; Shortle, G. Using the nutrient transfer continuum concept to evaluate the European Union Nitrates Directive National Action Programme. *Environ. Sci. Policy* **2011**, *14*, 664–674. [CrossRef]
26. Dalgaard, T.; Hansen, B.; Hasler, B.; Hertel, O.; Hutchings, N.J.; Jacobsen, B.H.; Jensen, L.S.; Kronvang, B.; Olesen, J.E.; Schjorring, J.K.; et al. Policies for agricultural nitrogen management-trends, challenges and prospects for improved efficiency in Denmark. *Environ. Res. Lett.* **2014**, *9*, 115002. [CrossRef]
27. Van Grinsven, H.J.M.; ten Berge, H.F.M.; Dalgaard, T.; Fraters, B.; Durand, P.; Hart, A.; Hofman, G.; Jacobsen, B.H.; Lalor, S.T.J.; Lesschen, J.P.; et al. Management, regulation and environmental impacts of nitrogen fertilization in northwestern Europe under the Nitrates Directive; a benchmark study. *Biogeosciences* **2012**, *9*, 5143–5160. [CrossRef]
28. Buckley, C. Implementation of the EU Nitrates Directive in the Republic of Ireland—A view from the farm. *Ecol. Econ.* **2012**, *78* (Suppl. C), 29–36. [CrossRef]
29. Lundqvist, G.; Gasper, D.; St. Clair, A.L.; Hermansen, E.A.T.; Yearley, S.; Øvstebø Tvedten, I.; Wynne, B. One world or two? Science–policy interactions in the climate field AU. *Crit. Policy Stud.* **2018**, *12*, 448–468. [CrossRef]
30. Ritter, C.; Jansen, J.; Roche, S.; Kelton, D.F.; Adams, C.L.; Orsel, K.; Erskine, R.J.; Benedictus, G.; Lam, T.J.G.M.; Barkema, H.W. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. *J. Dairy Sci.* **2017**, *100*, 3329–3347. [CrossRef] [PubMed]
31. Liu, T.; Bruins, R.J.F.; Heberling, M.T. Factors Influencing Farmers' Adoption of Best Management Practices: A Review and Synthesis. *Sustainability* **2018**, *10*, 432. [CrossRef] [PubMed]
32. Gatto, P.; Mozzato, D.; Defrancesco, E. Analysing the role of factors affecting farmers' decisions to continue with agri-environmental schemes from a temporal perspective. *Environ. Sci. Policy* **2019**, *92*, 237–244. [CrossRef]
33. Huang, Z.; Karimanzira, T.T.P. Investigating Key Factors Influencing Farming Decisions Based on Soil Testing and Fertilizer Recommendation Facilities (STFRF)—A Case Study on Rural Bangladesh. *Sustainability* **2018**, *10*, 4331. [CrossRef]
34. Kuehne, G.; Llewellyn, R.; Pannell, D.J.; Wilkinson, R.; Dolling, P.; Ouzman, J.; Ewing, M. Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy. *Agric. Syst.* **2017**, *156*, 115–125. [CrossRef]
35. Radin, B.A. Science and Policy Analysis in the U.S. Office of Information and Regulatory Affairs. *Adm. Soc.* **2018**, *50*, 161–185. [CrossRef]
36. Head, B.W. Toward More "Evidence-Informed" Policy Making? *Public Adm. Rev.* **2016**, *76*, 472–484. [CrossRef]
37. Mitcham, C.; Fisher, E. Ethics and Policy A2—Chadwick, Ruth. In *Encyclopedia of Applied Ethics*, 2nd ed.; Academic Press: San Diego, CA, USA, 2012; pp. 165–172.
38. Boswell, C.; Smith, K. Rethinking policy 'impact': Four models of research-policy relations. *Palgrave Commun.* **2017**, *3*, 44. [CrossRef]
39. Celis, J.E.; Gago, J.M. Shaping science policy in Europe. *Mol. Oncol.* **2014**, *8*, 447–457. [CrossRef] [PubMed]
40. EU. *Green Paper—The European Research Area: New Perspectives*; European Commission: Brussels, Belgium, 2007.
41. Norse, D.; Tschirley, J.B. Links between science and policy making. *Agric. Ecosyst. Environ.* **2000**, *82*, 15–26. [CrossRef]
42. Rich, R.F.; Oh, C.H. Rationality and Use of Information in Policy Decisions. *Sci. Commun.* **2000**, *22*, 173–211. [CrossRef]
43. Nightingale, P.; Scott, A. Peer review and the relevance gap: Ten suggestions for policy-makers. *Sci. Public Policy* **2007**, *34*, 543–553. [CrossRef]

44. Wildavsky, A. Views: No Risk Is the Highest Risk of All: A leading political scientist postulates that an overcautious attitude toward new technological developments may paralyze scientific endeavor and end up leaving us less safe than we were before. *Am. Sci.* **1979**, *67*, 32–37.
45. Jasanoff, S. STS and Public Policy: Getting Beyond Deconstruction. *Sci. Technol. Soc.* **1999**, *4*, 59–72. [CrossRef]
46. Sabatier, P.A. Toward Better Theories of the Policy Process. *PS Political Sci. Politics* **1991**, *24*, 147–156. [CrossRef]
47. Radaelli, C.M. The role of knowledge in the policy process. *J. Eur. Public Policy* **1995**, *2*, 159–183. [CrossRef]
48. Karjalainen, T.; Hoeveler, A.; Draghia-Akli, R. European Union research in support of environment and health: Building scientific evidence base for policy. *Environ. Int.* **2017**, *103* (Suppl. C), 51–60. [CrossRef]
49. Saltelli, A.; Giampietro, M. What is wrong with evidence based policy, and how can it be improved? *Futures* **2017**, *91* (Suppl. C), 62–71. [CrossRef]
50. Van Schendelen, R. The in-sourced experts AU. *J. Legis. Stud.* **2002**, *8*, 27–39. [CrossRef]
51. CORDIS. Community Research and Development Information Service—Projects and Results. Available online: http://cordis.europa.eu/projects/result_en?q=contenttype%3D%27project%27%20AND%20/project/acronym%3D%27%27water%27%27 (accessed on 12 October 2017).
52. WaterJPI. Joint Programming Initiative "Water Challenges for a Changing World". Available online: http://www.waterjpi.eu/water-jpi (accessed on 12 October 2017).
53. EC. *Monitoring and Reporting of Environment Legislation*; European Commission: Brussels, Belgium; Available online: http://ec.europa.eu/environment/legal/reporting/index_en.htm (accessed on 13 October 2017).
54. Dunlop, C.A.; Radaelli, C.M. Impact Assessment in the European Union: Lessons from a Research Project. *Eur. J. Risk Regul.* **2015**, *6*, 27–34. [CrossRef]
55. Lindblom, C.E. The Science of "Muddling Through". *Public Adm. Rev.* **1959**, *19*, 79–88. [CrossRef]
56. Weiss, C.H. Research for Policy's Sake: The Enlightenment Function of Social Research. *Policy Anal.* **1977**, *3*, 531–545.
57. Weible, C.M.; Heikkila, T.; deLeon, P.; Sabatier, P.A. Understanding and influencing the policy process. *Policy Sci.* **2012**, *45*, 1–21. [CrossRef]
58. Mollinga, P.P.; Bhat, A.; Cleaver, F.; Meinzen-Dick, R.; Molle, F.; Neef, A.; Subramanian, S.; Wester, P. Water, Politics and Development: Framing a Political Sociology of Water Resources Management. *Water Altern.* **2008**, *1*, 7–23.
59. Budds, J. Contested H_2O: Science, policy and politics in water resources management in Chile. *Geoforum* **2009**, *40*, 418–430. [CrossRef]
60. Prieur, F.; Zou, B. Climate politics: How public persuasion affects the trade-off between environmental and economic performance. *Math. Soc. Sci.* **2018**, *96*, 63–72. [CrossRef]
61. Hüesker, F.; Moss, T. The politics of multi-scalar action in river basin management: Implementing the EU Water Framework Directive (WFD). *Land Use Policy* **2015**, *42*, 38–47. [CrossRef]
62. Daniell, K.A.; Coombes, P.J.; White, I. Politics of innovation in multi-level water governance systems. *J. Hydrol.* **2014**, *519*, 2415–2435. [CrossRef]
63. Biscotti, A.M.; D'Amico, E. What are political leaders' environmental intentions? The impact of social identification processes and macro-economic conditions. *Ecol. Econ.* **2016**, *129*, 152–160. [CrossRef]
64. Martin-Ortega, J. Economic prescriptions and policy applications in the implementation of the European Water Framework Directive. *Environ. Sci. Policy* **2012**, *24* (Suppl. C), 83–91. [CrossRef]
65. Mostert, E. The European Water Framework Directive and water management research. *Phys. Chem. Earth Parts A/B/C* **2003**, *28*, 523–527. [CrossRef]
66. Hodgson, S.M.; Smith, J.W.N. Building a research agenda on water policy: An exploration of the Water Framework Directive as an interdisciplinary problem. *Interdiscip. Sci. Rev.* **2007**, *32*, 187–202. [CrossRef]
67. Lagace, E.; Holmes, J.; McDonnell, R. Science-policy guidelines as a benchmark: Making the European Water Framework Directive. *Area* **2008**, *40*, 421–434. [CrossRef]
68. Wemaere, A. Funding research to provide the evidence and the knowledge-base to inform and support policy in Ireland: The EPA Water Research Programme. *Boil. Environ. Proc. R. Ir. Acad.* **2016**, *116B*, 135–156. [CrossRef]
69. Quevauviller, P. European water policy and research on water-related topics—An overview. *J. Hydrol.* **2014**, *518*, 180–185. [CrossRef]

70. Beniston, M.; Stoffel, M.; Harding, R.; Kernan, M.; Ludwig, R.; Moors, E.; Samuels, P.; Tockner, K. Obstacles to data access for research related to climate and water: Implications for science and EU policy-making. *Environ. Sci. Policy* **2012**, *17* (Suppl. C), 41–48. [CrossRef]
71. Dunn, G.; Brown, R.R.; Bos, J.J.; Bakker, K. The role of science-policy interface in sustainable urban water transitions: Lessons from Rotterdam. *Environ. Sci. Policy* **2017**, *73* (Suppl. C), 71–79. [CrossRef]
72. Escribano Francés, G.; Quevauviller, P.; San Martín González, E.; Vargas Amelin, E. Climate change policy and water resources in the EU and Spain. A closer look into the Water Framework Directive. *Environ. Sci. Policy* **2017**, *69* (Suppl. C), 1–12. [CrossRef]
73. Doody, D.G.; Foy, R.H.; Barry, C.D. Accounting for the role of uncertainty in declining water quality in an extensively farmed grassland catchment. *Environ. Sci. Policy* **2012**, *24* (Suppl. C), 15–23. [CrossRef]
74. Brown, L.E.; Mitchell, G.; Holden, J.; Folkard, A.; Wright, N.; Beharry-Borg, N.; Berry, G.; Brierley, B.; Chapman, P.; Clarke, S.J.; et al. Priority water research questions as determined by UK practitioners and policy makers. *Sci. Total Environ.* **2010**, *409*, 256–266. [CrossRef] [PubMed]
75. Moss, T.; Newig, J. Multilevel Water Governance and Problems of Scale: Setting the Stage for a Broader Debate. *Environ. Manag.* **2010**, *46*, 1–6. [CrossRef] [PubMed]
76. Newig, J.; Pahl-Wostl, C.; Sigel, K. The role of public participation in managing uncertainty in the implementation of the Water Framework Directive. *Eur. Environ.* **2005**, *15*, 333–343. [CrossRef]
77. Reed, M.S. Stakeholder participation for environmental management: A literature review. *Biol. Conserv.* **2008**, *141*, 2417–2431. [CrossRef]
78. Özerol, G.; Newig, J. Evaluating the success of public participation in water resources management: Five key constituents. *Water Policy* **2008**, *10*, 639–655. [CrossRef]
79. McGonigle, D.F.; Harris, R.C.; McCamphill, C.; Kirk, S.; Dils, R.; Macdonald, J.; Bailey, S. Towards a more strategic approach to research to support catchment-based policy approaches to mitigate agricultural water pollution: A UK case-study. *Environ. Sci. Policy* **2012**, *24* (Suppl. C), 4–14. [CrossRef]
80. Martini, F.; Kinga, G.; Christos, F.; Benoît-Fribourg, B.; Amorsi, N.; Stephen, M., 3rd. CIS-SPI Event "Water Science Meets Policy: How to Streamline Knowledge to Address WFD Challenges?". Available online: http://www.onema.fr/EN/EV/plus/SPI-Brochure.pdf (accessed on 25 October 2017).
81. Reyjol, Y.; Argillier, C.; Bonne, W.; Borja, A.; Buijse, A.D.; Cardoso, A.C.; Daufresne, M.; Kernan, M.; Ferreira, M.T.; Poikane, S.; et al. Assessing the ecological status in the context of the European Water Framework Directive: Where do we go now? *Sci. Total Environ.* **2014**, *497* (Suppl. C), 332–344. [CrossRef]
82. Bressers, H.; O'Toole, L.J. Networks and water policy: Conclusions and implications for research AU. *Environ. Politics* **1994**, *3*, 197–217. [CrossRef]