Journal of Environmental Management 287 (2021) 112270

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

Research article

Protection of drinking water resources from agricultural pressures: Effectiveness of EU regulations in the context of local realities

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ARTICLE INFO

Keywords:
Drinking water resources
Nitrate
Pesticides
Water framework directive
Multi actor platform
Local governance

ABSTRACT

Over the last decades, nutrients and pesticides have proved to be a major source of the pollution of drinking water resources in Europe. Extensive legislation has been developed by the EU to protect drinking water resources from agricultural pollution, but the achievement of water quality objectives is still an ongoing challenge throughout Europe.

The study aims to identify lessons that can be learnt about the coherence and consistency of the application of EU regulations, and their effects at the local level, using qualitative expert data for 13 local to regional governance arrangements in 11 different European countries.

The results show that the complexities and inconsistencies of European legislation drawn up to protect drinking water resources from agricultural pollution come forward most explicitly at local level where cross-sectoral measures have to be taken and effects monitored. At this local level, rather than facilitate, they hamper efforts to achieve water quality objectives. The upcoming revision of the Water Framework Directive (WFD) should strengthen the links between the different directives and how they could be applied at local level.

In addition, a more facilitated cross-sectoral approach should be adopted to improve stakeholder networks, between institutional levels and hydrological scales, to attain policy objectives at local level.

1. Introduction

Currently, nitrates and pesticides are among the major sources of drinking water resources pollution in Europe (EEA 2018). In order to reduce and mitigate emissions from agriculture to water and protect the environment, the EU has developed an extensive regulatory and policy framework that addresses both water and agricultural sectors, environmental pollution and land use over the last decades (Platjouw et al., 2019). In addition to these legal obligations, many other initiatives have been developed at local and regional scales to further contribute to the protection of drinking water resources (Doody et al., 2012; Gravesgaard et al., 2018), some of which had already begun in the nineties

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https://doi.org/10.1016/j.jenvman.2021.112270
Received 13 October 2020; Received in revised form 20 January 2021; Accepted 22 February 2021
Available online 15 March 2021

(Quirin and Hoetmer 2019).

These initiatives were often triggered by an increased awareness that existing legal frameworks were insufficient to adequately protect drinking water resources from agricultural pollution (Keessen et al., 2011; Doody et al., 2012; Jacobsen et al., 2017). The directives had varying success in water quality improvement. The European Innovation Partnership on Water (EIP Water) identified the 'inconsistency and fragmentation of policies, regulations and governance structures' as 'low hanging fruit' whose improvement would greatly enhance the development of the sector (EC 2014). This article aims to contribute to the understanding how this 'inconsistency and fragmentation of policies, regulations and governance structures' impacts water quality improvement at the local level and what lessons can be learned from experiences so far. Governance is defined here as a process of interaction between public and/or private actors, ultimately aiming at the achievement of collective goals, including the knowledge, instruments and means to do so (Lange et al., 2013).

The inconsistency noted by the EC (2014) can to some extent be explained by the development of European environmental legislation over time. At first, directives focused on the protection and restoration of water quality for specific water functions like drinking water (DWD, 75/440/EEC) and groundwater (80/68/EEC). During a second phase, directives focused on the reduction of emissions such as the Nitrates Directive (ND, 91/676/EEC), the Sustainable Use of Pesticides Directive (SUPD, 2009/128/EC) the Urban Wastewater Directive (UWWD, 98/15/EC) and the Integrated Pollution Prevention Control Directive (IPPC, 96/61/EC). In this phase, legislation addressed water quality issues from a sectoral point of view and less attention was paid to stakeholder involvement (Van Rijswick and Havekes 2012). A third phase in the development of European water quality law can be identified with the introduction of the Water Framework Directive (2000/60/EC), reflecting the growing awareness that complex water issues cannot be addressed by legislation alone and are specific to a river basin (OECD 2015a, 2015b; Howarth 2017). The WFD, with its river basin approach, requires new governance arrangements for cross-sectoral cooperation with other stakeholders, both within and between Member States.

The shift towards governance-based approaches can be seen in national policies as well, although differences exist between Member States (Rowbottom et al., 2019). Several scholars noted that the mode of implementation[1] is often adapted to existing national regulatory and policy structures, in accordance with the principle of subsidiarity, but research has shown that this mode of implementation may also impact its effectiveness (Keessen et al., 2010; Giakoumis and Voulvoulis 2018; Birkenstock and Röder 2019). Even more, building on existing national regulatory and policy structures for the implementation of EU legislation may also be the cause of the inconsistencies and fragmentation of policies in the achievement of the European ambitions (Keessen et al., 2010; Birkenstock and Röder 2019). Coherence and consistency are key factors if we are to have a successful EU regulatory and policy regime that aims to prevent, and manage, the diffuse pollution of drinking water resources caused by agriculture. At regional and local scales, it may become clear whether the coherence and consistency between these policy domains is addressed well enough to achieve policy objectives.

In this context, coherence is defined as the extent to which laws and policies systematically reduce conflicts and promote synergies between, and within, different policy areas to achieve jointly agreed policy objectives (Nillson et al., 2012). A sectoral policy can be effective in achieving its specific objectives without being coherent in relation to the objectives of other policy areas (Platjouw et al., 2019). Consistency marks the extent to which the jointly-agreed policy objectives can be recognised at different levels, and within different policy arenas, and there is no contradiction between them.

Several publications address the importance of analysing the impact of governance on water quality outcomes (e.g. (Newig and Fritsch 2009; Blackstock et al., 2012)). So far however, little empirical research has been done on the local governance arrangements that could contribute to better groundwater and surface water quality (Wuijts et al., 2017); studies are often of an aggregated national or European level, for instance to evaluate the implementation of a particular Directive (EC 2018; EC 2019).

This article aims to discuss from the local-regional perspective, (1) whether the different parts of EU legislation and their mode of implementation strengthen or block one another, (2) whether local governance arrangements can overcome potential gaps or spill-over effects in this legal framework and (3) what lessons can be learnt to improve the protection of drinking water resources from agricultural pressures. To this end, governance arrangements in 13 case study areas in 11 European countries were analysed, using the OECD principles on water governance (OECD, 2015b) as the analytical framework and tested on the criteria coherence, consistency and the attainment of objectives at the local level.

2. Methodology

2.1. Case studies

The effectiveness of EU legislation on the restoration of drinking water resources and their protection from agricultural pollution was examined using empirical research as carried out in the H2020-FAIRWAY-project (www.fairway-project.eu, last accessed January 12th, 2021). For 13 case study areas in Denmark, England, France, Germany, Greece, the Netherlands, Northern Ireland, Norway, Portugal, Romania and Slovenia, Multi Actor Platforms (MAPs) were installed or are under construction aiming to facilitate aspects of local-regional governance approaches (Sundnes et al., 2020). These MAPs are a more-or-less ongoing mechanism for actors from different sectors and levels, including farmers, advisors, drinking water companies, scientists and policy makers, to meet regularly to foster the exchange of ideas and initiatives and promote joint decision-making and collaboration in a continuously evolving way (Acquaye-Baddoo, 2010). The size of these case study areas varies as a consequence of both institutional settings and water system characteristics, ranging from a few hundred km^2 to tens of thousands of km^2 (local to regional scale). The 13 case study areas cover different types of drinking water resources, pedo-climatic zones, type of farming, land use, legal framework, and governance approaches used, and offer a pan-European view of experiences with local governance arrangements for the protection of drinking water resources from agricultural pollution (Sundnes et al., 2020). Table 1 presents an overview of the case studies used in our analysis. More detailed descriptions of the case studies can be found on https://www.fairway-project.eu/index.php/case-studies (last accessed January 12th, 2021).

In this article, three of these 13 case studies will be presented more extensively as they elucidate some of the key results of our analysis and demonstrate local experiences. These are the cases from Northern Ireland (Derg Catchment), Germany (Lower Saxony) and Greece (Axios River).

2.2. Analytical framework

The literature contains many descriptions of frameworks for analysing conditions of water governance (e.g. (Pahl-Wostl et al., 2012; Van Rijswick et al., 2014; OECD, 2015b)) and although these frameworks encompass similar elements, they differ in terms of accents and scope (Wuijts et al., 2017). For instance, the analytical framework drawn up for sustainable water governance (Van Rijswick et al., 2014) has a

[1] The term 'implementation' refers to an explicit phase in the policy process: the execution of interventions to achieve policy objectives. It also refers to the transposition of European legislation into national law. In this article the focus is on the attainment of policy objectives. To avoid confusion regarding the use of the term 'implementation', the term 'attainment' is used.

Table 1
Overview of case studies.

Country	Name	Type of Resource for Drinking Water	Principal Water Quality Issue(s)	
			Nitrates	Pesticides
Denmark	Island Tunø	Groundwater	X	X
Denmark	Aalborg	Groundwater	X	X
England	Anglian Water	Surface water		X
France	La Voulzie	Groundwater (springs)	X	X
Germany	Lower Saxony	Groundwater	X	
Greece	Axios river	Groundwater and surface water	X	X
Netherlands	Province of Overijssel	Groundwater	X	X
Netherlands	Province of Noord-Brabant	Groundwater		X
Northern Ireland	Derg catchment	Surface water		X
Norway	Vansjø	Surface water	X	
Portugal	Baixo Mondego	Ground and surface water	X	X
Romania	Giurgiu county	Groundwater	X	
Slovenia	Dravsko Polje	Groundwater	X	X

diagnostic nature with an explicit focus on implementation and the attainment of objectives. The framework developed by Pahl-Wostl et al. (2012) aims to compare and quantify the governance approaches used in different river basins. This scale, however, is too aggregated for the purpose of our study (local to regional scale). The investigation of local-regional governance arrangements for attainment of EU objectives, requires a framework that facilitates an analysis across scales, encompassing both the national implementation and the local to regional experiences with the attainment of objectives. For this reason, the OECD Water Governance Principles (2015) were used as a framework for our analysis.

The OECD principles are based on the general principles of good governance: legitimacy, transparency, accountability, human rights, rule of law and inclusiveness (OECD, 2015b). The framework contains three mutual reinforcing dimensions: Effectiveness, Efficiency and Trust and Engagement. Data has been collected for all twelve principles of the analytical framework. Since this article focuses on the criteria coherence, consistency and the attainment of objectives at local level, the results related to these criteria are described here (see Table 2). A full summary of data can be found in the supplementary material.

2.3. Questionnaires

The national implementation and the resulting local-regional governance arrangements in the case studies served as the unit of our analysis; an analysis which was carried out in four consecutive steps.

Firstly, the four principles related to the Effectiveness dimension were broken down into 37 questions which were put into questionnaires for each of the case studies. The questionnaire was developed based on information from literature (OECD 2009; OECD 2015a, 2015b; Nava et al., 2016; Belmans et al., 2018; UN 2018), and the questions themselves related to different institutional levels and geographical scales, so that the coherence and consistency of EU legislation could be analysed at the local-regional level, as well as the implementation at the national level. As EU directives are often implemented on a sectoral basis (Keessen et al., 2011), the questionnaire applied to each of the relevant directives. The respondents to the questionnaires varied: some, for example, were filled out by the experts and MAP coordinators involved in the FAIRWAY project. For each country, 2 to 6 respondents filled out the questionnaires. If this expertise was not present in the project, external policy makers and experts were consulted who had a regional to local view. For all cases, the questionnaires were completed by multiple respondents and the results were discussed when different views arose.

Secondly, the principles within the other two dimensions of the analytical framework, Efficiency and Trust and Engagement, were analysed, such as regulatory frameworks, monitoring and evaluation and stakeholder engagement. To this end, a set of 14 questions was formulated. These questions were derived from an earlier study on governance approaches regarding drinking water resources in the Netherlands (Wuijts et al., 2017). The answers to the questions were delivered in writing and then clarified further during carousel discussion sessions with the MAP coordinators. Both questionnaires can be found in the supplementary material.

Thirdly, the data were aggregated per principle and per country for further analysis. All the questionnaires that were filled out were collated in a spreadsheet, one for each directive studied, containing the results of all the individual questions, and clustered for the different OECD principles. Consequently, the results of the individual questions were first combined into a synopsis for the different directives, but separately for the different case studies and countries. Subsequently, the results were aggregated into a summarising text for each of the principles covering all of the case studies. Two researchers from different countries in the FAIRWAY project carried out the aggregation of results individually and subsequently compared and discussed the results to avoid interpretative errors. The results of the analysis were reported back to the MAP coordinators for feedback and discussion.

Finally, the answers for the different countries were summarised into one concluding answer for each question, leaving room to highlight differences and similarities in implementation strategies between directives and countries that might affect effectiveness. These results were reported back to the experts and stakeholders involved for feedback and discussion. The different stages of the data collection and analysis are depicted in Fig. 1.

Table 2
OECD Water Governance Principles (OECD, 2015b) that are included in the analysis of the criteria consistency, coherence and, mode of implementation and the attainment of objectives at local level.

Dimensions and Principles Analytical framework (OECD, 2015b)		Criteria for analysis		
		Consistency of EU regulation	Coherence across sectors and levels	Attainment of objectives at local level
Effectiveness	Capacity	X		X
	Policy coherence		X	X
	Appropriate scales within basin systems	X	X	X
	Clear roles and responsibilities	X	X	
Efficiency	Regulatory frameworks in place and enforced		X	X
	Data and information			X
Trust and Engagement	Trade-offs across users, areas, and generations			X
	Stakeholder engagement	X		
	Integrity and Transparency		X	

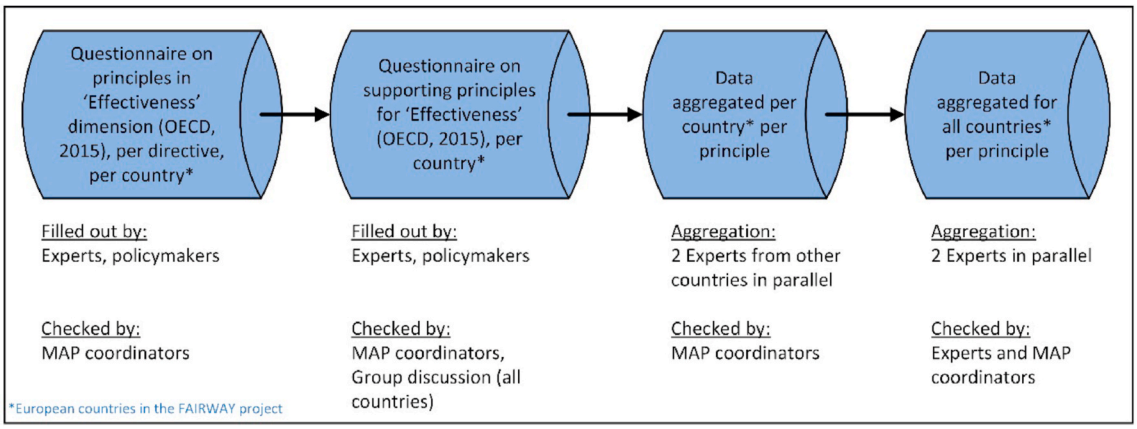

Fig. 1. Data-collection and analysis.

2.4. Limitations and uncertainties

Data for this study was collected through interviews and questionnaires. Policy documents and (grey) literature on the case studies were used as additional source of information. Using this methodology meant that the results relied strongly on the level of expertise of the interviewees. Information not provided by an interviewee could thus be lacking in the analysis. Checks and balances were included in the process of data analysis to overcome this potential bias, by requesting that the questionnaires were filled out by pairs or groups, by complementing the questionnaires with group discussions with experts from other countries and cases, by analysing the data-set in parallel for countries other than your own and by asking the MAP coordinators to reflect on the final dataset.

3. Results

In accordance with the central question of this analysis, this section is structured around three elements: (1) consistency of EU regulations, (2) coherence across sectors and levels, and (3) mode of implementation and the attainment of objectives at local level. The responses to the questions that are relevant to these elements are described here.

The total results of the aggregated questionnaires are summarised in the supplementary material.

3.1. Consistency of EU regulations

Consistency manifests itself in the degree to which commonly agreed policy objectives are recognised at different levels by different stakeholders and within different policy arenas. They must not contradict each other and this requires clarity about roles and responsibilities, and management across scales.

3.1.1. Principle: clear roles and responsibilities towards objectives

All the countries studied have transposed the relevant EU directives into national law. The allocation of roles and responsibilities for each directive is clearly demarcated at national level in the planning phase, although assigned to different ministries. For the regional/catchment, local and farm level, the division of these roles and responsibilities for (strategic) planning for water quality ambitions often becomes less clear from the perspective of the respondents, although in all of the countries studied, farmers have to prepare a plan for the use of fertilisers.

3.1.2. Principle: appropriate scales within basin systems

In most countries studied, except in the UK, different ministries are responsible for agricultural policy and environmental protection. The collaboration at national level between ministries and between water authorities was reported as being in place and working more or less for all the countries studied. The issue of governance at the appropriate scale within basin systems or other relevant scales, is not regarded as a major issue affecting effectiveness for the countries studied. More difficult is the involvement of different sectors, government departments and administrations, in addressing water quality issues from agriculture at different institutional levels and scales (e.g. Greece, Germany). At river basin and catchment level, good collaboration was reported too (e.g. Denmark, France and Norway) but not for all countries. In these collaborations, farmers' organisations are represented in several cases. The level of direct collaboration with individual farmers, however, differs between the countries studied.

3.1.3. Principle: capacity (towards objectives)

Authorities in most cases have the capacity to lead, monitor and evaluate the execution of policy plans. Lack of staff and finances was frequently reported as an obstacle to carrying out all responsibilities (e.g. Germany, especially at the legislative level, and England). A decrease in these resources cascading from the national level to the regional/catchment level can be identified in some countries according to the interviewees (e.g. Greece, Netherlands), but it can also be the other way around: lack of staff at the top, national level, and sufficient staff at the bottom, e.g. providing farm advice (Germany).

3.1.4. Principle: stakeholder engagement

Stakeholders involved include public authorities, water companies, farmers' organisations, industry associations, NGOs and experts, such as agricultural advisors and consultants. Several institutional levels are involved in the attainment of objectives at local level and interaction with stakeholders does not take place at all levels. In the case studies, farmers and local citizens are given the opportunity to be engaged. For some countries the stakeholder engagement set-up for the MAP in the case study is reported as a new way of collaboration (e.g. Slovenia, Romania and Greece).

Stakeholders in the MAPs of the case studies were engaged based on their interest in clean water, local knowledge, knowledge on best practices, such as catchment advisors (e.g. England, Portugal), sources of pollution (e.g. Slovenia, Netherlands, Germany, Denmark, Norway), established networks (e.g. Northern Ireland, Germany, Portugal) and the means and power to act (e.g. Slovenia, Romania, Denmark). Norway reports that commercial private actors have not yet been included in the river basin committee because of their primarily economic focus. However, the importance of their role in the process has been acknowledged and dialogue is being channelled through other meeting arenas. Other reasons for restrictions are group size (to allow discussions) and costs (advisors), and England reports that some stakeholders are reluctant to speak if the regulator is also part of the stakeholder

group.

Some countries report that different authorities from different institutional levels participate in the case study (e.g. Germany, Norway, France). Others report that there is a disconnect between the different levels (e.g. Greece) or a single layer governance approach (Slovenia). This may also differ for different case studies and regions in a country (e.g. Germany).

All countries stress the importance of environmental information, although socio-economic implications may play a major role in the decision-making when stricter measures need to be implemented (Germany). Citizen engagement has only been used in a limited way so far in the process of decision-making regarding the protection of drinking water resources. In Germany, there is a citizen science initiative which is collecting water samples and analysing nitrates from private groundwater extraction points and from surface waters (ähttps://www.xn–vsr-gewsserschutz-wqb.de/nitratbelastung/, last accessed January 14th, 2021) and an initiative which is working on the methodology and publishes manuals in order to improve the validity of nitrates analysis (https://uol.de/aktuelles/artikel/stickstoffverbindungen-und-die-neugier-an-der-wissenschaft-3775, last accessed on January 14th, 2021). In England, citizen science is considered a fundamental opportunity for understanding and promoting local engagement in the Catchment Based Approach (https://catchmentbasedapproach.org/learn/citizen-science-volunteer-monitoring/, last accessed January 12th, 2021). Other factors mentioned as relevant in the process of decision-making are the overriding interest of the right to drinking water (Slovenia) and the costs for providing good quality drinking water (France).

3.1.5. Experiences with consistency in the derg catchment case study

Textbox 1 outlines how the inconsistencies between EU directives and its application at farm level can negatively impact water quality in the Derg catchment case study (Republic of Ireland – Northern Ireland); a study which highlights the complexity of the interactions between European and national agri-environmental legislation, EU subsidy payments and catchment characteristics. In some cases these interactions can have detrimental impacts on water quality. The ND and SUPD limit agricultural pressure in intensively farmed catchments. However, in more marginal upland catchments they enable farmers to operate above the carrying capacity of the soil by including marginal land, cleared of rushes, in the total farm organic N loading calculations required for the ND. However, in practice, this livestock is often concentrated on the small number of higher-quality grazing fields on the farm, resulting in higher nutrient loads.

Furthermore, receipt of the Basic Payment Scheme (BPS) of the Common Agricultural Policy (CAP) is a vital income source for cattle and sheep farmers in upland catchments. In 2017/18, the cattle and sheep sector in Northern Ireland would have operated at a loss if the income from the BPS had been removed (DAERA, 2019b). Farmers are under pressure to maximise the eligible area for the BPS on their farm, the main driver for the control of rushes using MCPA. At the same time this hampers the sustainable preservation of drinking water resources.

3.2. Coherence across sectors and levels

Coherence elucidates the extent to which laws and policies systematically reduce conflicts and promote synergies between, and within, different policy areas to achieve the outcomes associated with jointly-agreed policy objectives (Nillson et al., 2012), imposing demands on regulatory frameworks, roles and responsibilities, decision-making and management across scales.

3.2.1. Principle: clear roles and responsibilities

The tools reported which facilitate collaboration in water quality management at a specific level (horizontal collaboration) are: (1) a pesticide forum that brings together a range of organisations and is highlighted as having a key role under the national action plan in providing stakeholder interaction (England), (2) incentives from cross compliance and enforcement to adherence of good agricultural practice (Slovenia, Portugal and Germany), (3) interdepartmental committees and county offices (Romania and Norway), (4) advisory boards for river

Textbox 1
Consistency agricultural and water quality policy in the Derg catchment.

The poorly drained, acidic and nutrient-poor soils in the Derg catchment provide ideal conditions for the proliferation of rushes (*Juncus* sp.), which easily outcompete grasses in the absence of preventive management (Kaczmarek-Derda et al., 2019). At present, mapping indicates that rushes occupy approximately 5% of agricultural land in the catchment, which reflects efforts to suppress rushes and maintain grass cover (Cassidy 2018). These efforts are driven by targets set by both intensive and extensive farms in the catchment. In an intensive dairy system the control of rushes is driven by production and nutritional targets, while in part-time low intensity beef and sheep systems the main driver is to maximise the land area classed as “actively farmed” and eligible for area-based payments under the common agricultural policy (CAP) basic payment scheme (BPS). As such maintaining and maximising the eligible area, is a priority for both intensive and extensive farms in the catchment.

The eligible agricultural land area declared under the BPS is also used to calculate the organic N loading for each farm under the EU Nitrates Directive (ND) (91/676/EEC). The ND sets a limit of 170 kg organic N/ha which equates to a stocking rate of 2 Livestock Units (LSU)/ha. Exceeding this limit is only permissible if the farm applies for a derogation.

While farmers are required to apply the Code of Good Agricultural Practice for grazing (DAERA, 2008) in order to prevent *inter alia* compaction, poaching and erosion, in practice stocking rates are often higher that suggested by estimates of grazing capacity. For example, based on the 2018 returns from the farm census (DAERA 2019), the current average stocking rate in the catchment is 2.4 LSU/ha. This figure indicates that the overall stocking rate in the catchment is above the carrying capacity of the soil and can only be maintained through measures such as the installation of artificial drains and the intensive management of land through nutrient applications, liming, grazing, cutting, harvesting and reseeding.

In addition, the use of herbicides, particularly 2-methyl-4-chlorophenoxyacetic acid (MCPA), to suppress rush growth is widespread. Because there are only a limited number of fields available to produce high dry matter forage crops, farmers will periodically apply MCPA to these fields to reduce the risk of rushes or other broad leaf weeds impacting silage quality. In less intensively managed areas, while stock numbers are low, spraying of MCPA offers farmers a cost-effective and long lasting option for suppressing rush growth and maintaining grassland as ‘actively farmed’, but with negative impacts on environmental quality. The combination of these measures to maintain stocking density can result in significant negative impacts on water quality. A recent monitoring program in the Derg catchment showed that 32% of the abstracted water, sampled every 7 h over an 8 month period in 2018, exceeded the drinking water standard of 0.1 μg/l for MCPA.

basin management committees (Portugal), state regional representatives (France), (5) water councils (Denmark) and (6) a leading role for water agencies (Slovenia). Collaboration tools reported which facilitate policy coherence are focused primarily at national or river basin level, although there are exceptions.

In Germany for instance, joint working groups are meeting regularly for coordination purposes at national, federal, and river basin levels for both the WFD and the ND.

Obstacles to effective horizontal collaboration between different authorities and agencies mentioned are: competing interests between sectors and institutional levels (Norway, England, Germany, Romania, Slovenia), municipal stakeholders being involved in the management of water companies (e.g. England, Portugal), the lack of monitoring data (Slovenia) or access to data (France, Germany), limited decision-making powers or round table setting (Germany), lack of staff (Germany [at national level] and France) and citizen engagement (Portugal).

3.2.2. Principle: appropriate scales within basin systems

The issue of management at appropriate scales is not regarded as a major issue hindering coherence for the different countries studied but the involvement of different sectors working in the field of agriculture and water quality is considered to be more relevant (e.g. Germany and Greece). River basin management committees (Slovenia, Netherlands, France and Denmark) and sub-basin committees (Norway) are reported as successful bridging mechanisms between different sectors. Similar examples are given for protection zones and nitrate vulnerable zones. The whole of Slovenia, because of its size, has been designated as a nitrate vulnerable zone and all issues are, therefore, addressed at national level. A similar approach has been followed by Austria and the Netherlands. This choice however, sets demands to the monitoring of nitrates in order to identify agricultural contributions (91/676/EC, Article 5.6) and develop appropriate nitrate action programmes (ECJ case law (C-481/18, C-197/18)). Germany cites a working group for the sustainable use of pesticides implementation (participated in by national and federal governments) as a good example of the bridging between administrative borders.

3.2.3. Principle: policy coherence

Instruments which were reported to promote policy coherence relevant to horizontal collaboration in water quality governance, include: multi-sectoral conferences (e.g. Germany, Greece, Norway), conferences for transboundary river basins (Portugal, Romania), interdisciplinary workshops (Netherlands), inter-agency programmes for specific issues (Northern Ireland, Portugal and Norway), information sharing with the agri-food-industry (Northern Ireland) and guidance on best practices (England). Some countries reported limited horizontal communication (e.g. France, Greece) and lack of clarity in responsibilities (water and agriculture).

3.2.4. Principle: regulatory frameworks in place and enforced

Regulatory frameworks and enforcement play an important role in achieving jointly-agreed policy objectives, although there are different views regarding the right balance between voluntary and legally-based measures to support these objectives. Some countries rely primarily on legally-based measures (e.g. Portugal, Germany) and thus have a strong role for enforcement, other countries are more committed to voluntary measures and enforcement plays a less important role in practice (e.g. Netherlands, France), or there is a mix of both types of measures (e.g. Denmark and Norway). Economic incentives, such as compensation, play an important role in relation to both voluntary and mandatory measures (e.g. Denmark, Germany and Norway). Norway refers to the information provided by the municipal agricultural advisor, the MAP coordinator and research projects as an incentive, for instance in cases where there is disagreement about the cause of a problem.

3.2.5. Principle: transparency and integrity in decision-making

Conflict prevention and resolution are addressed in different ways. For example, Northern Ireland refers to the communication plan in The Rivers Trust for the Source To Tap project as a means, Germany (Lower Saxony) to Round Tables for Agriculture and Water Protection and the Netherlands to the agricultural advisor as arbiter. Legal procedures are rarely used in practice for conflict resolution regarding nitrate and pesticide pollution e.g. caused by difficulties related to control and proof of an offence (Germany).

Mechanisms reported to support conflict management and resolution are the arbiter role of the municipal agricultural advisor and MAP coordinator (Norway, Netherlands), cross-compliance (Portugal), financial incentives (Germany: Farmer-waterworks cooperation), compensation and land consolidation (Denmark), agricultural support (France, Germany), public consultation and the role of civil initiatives (Slovenia).

3.2.6. Experiences with coherence in the Lower Saxony case study

The Lower Saxony case study (Germany, see Textbox 2) describes how parallel policy objectives regarding biogas production and fertilisation can result in negative impacts on water quality. Increasing amounts of manure and biogas by-products create a bottleneck in their application in regions with high livestock densities, resulting in rising nitrate levels in groundwater. To remediate this development, manure treatment and export to other regions and federal states are increasing (Landwirtschaftskammer Niedersachsen 2020). In regions with a focus on arable farming and little livestock breeding, there is potential to substitute part of the mineral fertilisers with manure from the intensive animal breeding regions. However, there are many factors which hamper application in practice such as: (1) the limited nitrogen surplus which is legally acceptable according to the German Fertilisation Ordinance (2017, 2020) and the possibility of exceeding this limit when using manure or other organic fertilisers; farmers in arable regions under this condition tend to use mineral fertilisers, (2) obstacles to improving the nitrogen efficiency of fertilisation by the timely supply of baseline data (N_{min}-values in spring) to farmers by farm advisors and delays in the national implementation of new techniques, (3) the possibility of health risks related to untreated manure caused by limited hygiene standards for farmyard manure in the Fertiliser Ordinance (2012) and (4) the lack of manure storage capacity in arable farming areas, as local authorities hesitate, or even refuse, to grant building permits for storage facilities. Due to pressure from the European Commission, the duty to set up a nitrogen soil surface budget and the necessity of not exceeding a certain level of nitrogen surplus was abolished and replaced by the duty to record the fertilisers applied (Fertilisation Ordinance, 2020).

3.3. Mode of implementation and the attainment of objectives at local level

The role of the mode of implementation and the attainment of objectives at local to regional level comes forward most explicit in the questions related to the principles ‘Appropriate scales within basin systems’, ‘Policy coherence’, ‘Capacity’, ‘Data and information’, ‘Regulatory frameworks in place and enforced’ and ‘Trade-offs across users, rural and urban areas and generation’.

3.3.1. Principle: appropriate scales within basin systems

Management instruments to support drinking water pollution control are used by all the countries studied, but different strategies are chosen by individual countries to facilitate use across levels and scales. England and Germany report a high degree of advice and guidance for farmers at catchment and farm level to support the implementation of a high level of regulation cascading from national and regional levels. Slovenia, Germany and Portugal stress the strong role of enforcement and cross-compliance. Other countries refer to the importance of

Textbox 2
Coherence water, fertilisation and energy policy: case study Lower Saxony (Germany).

Since 2000, the installation of biogas plants has been subsidised as a result of the passing of the German Renewable Energy Act (EEG, 2000, 2004, 2008). The law was adopted in 2004 and 2008, each time with more favourable conditions for the electric energy produced by cogeneration units of biogas plants. From the beginning of 2009, biogas plants operating with >30% manure received even higher subsidies. As a result, the number of biogas plants installed increased from 600 in 2010 to 1174 in 2018 (3N Kompetenzzentrum, 2020) and, in turn, increases the total amount of organic fertilisers (Meergans and Lenschow, 2018). The German Fertilisation Ordinance (2007), and the national implementation of the Nitrates Directive (1991), could not block this development, as the 170 kg/ha limit it prescribed for organic nitrogen in the national implementation only referred to N from animal manure. Consequently, after years of decreasing concentrations of nitrates, since 2011/2012 in the north-western region of Lower Saxony, the trend for the average yearly concentration of nitrates in groundwater of selected wells reversed and showed a marked increase in 2017 exceeding nitrate standard of 50 mg/l (Roskam 2018).

To counter this development, Lower Saxony issued a ministerial decree (ML, MS, MU, 2015), which obliged biogas plants to provide references to prove that the biogas residues they produce would be used according to the good agricultural practice defined in the national Fertilisation Ordinance.

In the adapted German Fertilisation Ordinance (2017), the 170 kg/ha limit also includes other types of organic and organic-mineral fertilisers and soil conditioners besides manure such as biogas residues, compost and sewage sludge.

monitoring and reporting and the development of programmes of measures from the WFD (e.g. France, Norway, Denmark). For Greece, a large variation was reported between management instruments used for the different directives. In Norway regional drinking water authorities are invited to comment on municipal spatial planning.

The designation of safeguard zones around drinking water resources was frequently put forward as a successful instrument for protection. Other (mandatory) instruments mentioned are the use of monitoring to support the evidence base and the development of programmes to support a sustainable use of pesticides (education on use by farmers, e.g. Portugal, Norway, Germany and UK ['Get Pelletwise' Campaign]) and manure (nitrate vulnerable zones, Greece).

3.3.2. Principle: policy coherence

Vertical coordination across different levels of governance in relation to nitrate usage is reported as limited for several countries. Obstacles reported are data protection at farm level (Germany), a disconnect between national policy and bottom-up initiatives (Netherlands, England), fragmentation of policy objectives (Norway), overlapping responsibilities (Greece) and a lack of funding for local collaboration (Greece, Slovenia).

3.3.3. Principle: capacity (at the local level)

Several governance measures were adopted by countries to build capacity to deliver water policy measures. Collaboration with the private sector (public authorities, private water companies and the agri-food industry) is reported. In England, the agency called Natural England (a non-departmental public body, sponsored by Defra) has teams of catchment advisors. This organisation enhances collaboration further by contracting private consultants to deliver water advice to farms. The Environment Agency makes Catchment Base Approach (CaBA) grants available to host catchment's partnerships. Some countries report the blocking role of GDPR (General Data Protection Regulation, EU/2016/679) for data sharing between local projects.

3.3.4. Principle: data and information

Most countries studied report that measures taken are based on knowledge of issues, interventions that could be enabled, and the opportunities offered by the legal framework which vary from country to country as their legal frameworks differ. Several countries rely on voluntary based measures where interventions may be linked less explicitly to nitrate and pesticides reduction and may be driven by economic motivations as well. Knowledge is based on scientific studies and best practices in other areas. Agricultural advisors play an important role. Not enough feedback has been received about the use of 'learning by doing' (adaptive capacity) to improve the effectiveness of interventions.

3.3.5. Principle: regulatory frameworks in place and enforced

The role of legally based measures varies strongly between countries, but this does not provide any indication as to the mode of implementation at the local level. Countries may have opted for a larger proportion of voluntary based measures and yet have attained the objectives at local level. The link between voluntary measures and water quality improvement is more ambiguous, because other interests, from farmers or other stakeholder groups, may play a more important role. Legally based measures on the other hand, should be achievable, enforceable and capable of reducing emissions to the levels required (e.g. ECJ case law C-266/99, C-165 to 167/09, C-237/07). This level of scrutiny is required in all environmental compartments, according to the European Commission (EC 2017).

3.3.6. Principle: Trade-offs across users, rural and urban areas, and generations

The role of trade-offs in costs, benefits and distributional effects of various alternatives in agreed service level decisions, is dependent on how many of the measures that need to be taken are legally based. Portugal for instance, which has a strong legal base for the measures that need to be taken, uses the 'polluter pays' principle, which is anchored in the legal framework. For other case studies, which rely more on voluntary based measures, a balanced trade-off between costs and benefits for farmers, is much more prominent in the selection of measures (e.g. Denmark, Netherlands, Northern Ireland and Norway).

3.3.7. Experiences with mode of implementation and objectives' attainment in the Axios case study

The Axios case study (Greece) (see Textbox 3) shows how the introduction of the MAP can serve as a bridging mechanism to promote coherent policy implementation and objectives' attainment at local level. So far, complicated and fractured legislation, unclear or overlapping responsibilities, the lack of rules for verification and validation, the distribution of financial means across institutional levels and the limited use of instruments for compliance and enforcement have been reported as factors hampering the realisation of water quality ambitions.

Farmers are often not very aware of their legal obligations regarding water quality. Most of the farms in this part of Greece are family businesses with small capital and no long-term plan. Farmers would, therefore, need incentives such as capacity building and starting grants for every single change in their production, but the continuity of such incentives is a point of concern.

Textbox 3
Mode of implementation and objectives' attainment in the Axios case study (Greece).

The ruling of the European Court of Justice (ECJ, C-149/14) that the implementation of the ND in Greece lacked any targeted action programmes has resulted in the development of Nitrate Action Programmes in the Nitrate Vulnerable Zones, but their implementation is taking place at a slow pace. In this process, a disconnect can be identified between the policy making at national level and the realisation at regional or local level.

The local discontent regarding the overlapping legislation, the multitude of institutions and government services responsible for planning and implementation, and the pressure from the European environmental legislation, have led to the establishment of the Directorate of Environment, Industry, Energy and Natural Resources of Central Macedonia Prefecture that cooperates with the local directorate of development and environment of the Kilkis Prefecture.

This rearrangement created a more centralised approach in the management of water resources, leading to a better and higher funding opportunity for large waterworks and a top-to-bottom implementation of rules and legislation from the EU and the establishment of directorates for water management in every region. In this way, the legislation became somewhat clearer at local to regional level and the problems for each region became apparent. But the small and everyday issues are not addressed this way, so the role of regional water utilities and water councils should be strengthened.

To this end, a multi-actor approach (MAP) was set up in the Axios case study area to address groundwater pollution. The MAP aims to involve farmers, companies providing advice, regional government, water boards, the pesticide industry, farmers, contractors, public authorities, and consumers and inform them about the monitored effects of their practices on water quality objectives and facilitate action.

So far the interest shown by farmers and other stakeholders in being part of the developed MAP has been higher than expected. The financial crisis of 2012–2020, brought dramatic changes. Young farmers, permanently living in the area, take over from past generations and introduce new ideas. The farmers are keen to be informed on new legislation, funding opportunities and they actively and consciously connect environmental quality to their quality of life and their products' quality. Nevertheless, they feel detached from the decisions of the main government and they have special, localised and differing needs in different parts of the country, even in the case study area.

4. Discussion

This study analysed the implementation of EU regulations in 11 different European countries and their effectiveness in 13 local governance arrangements for the protection of drinking water resources against agricultural pressures. We focussed on lessons that could be learnt regarding the coherence and consistency of the implementation of EU directives and their effects at local level. A summary of the results can be found in Table 3. The OECD Principles on Water Governance (OECD, 2015b) were used as our analytical framework (see Table 3).

4.1. Complexities and inconsistencies of the european legal framework

At EU level, regulations and policies for agriculture and the protection of drinking water resources are explicitly linked (Platjouw et al., 2019). For instance, the Nitrate Directive (91/676/EEC) links to the objectives of the Drinking Water Directive (98/83/EC) and the WFD (2000/60/EC) forms an overarching framework for EU directives regarding specific water functions (e.g. drinking water, shellfish waters, bathing water), the use of chemicals and their effect on the environment and the state of Europe's waters themselves. Although the directives are linked, their implementation produces collateral effects that hamper the effective protection of drinking water resources. The rules on the application of fertilisers, for example, are not always beneficial to groundwater and drinking water quality.

The implementation of the EU Directives often takes place along parallel tracks, and frequently under the responsibility of different ministries. Inconsistencies in agricultural policy that hamper an effective protection of drinking water resources, may therefore not manifest themselves at first sight and at all institutional levels. Examples reported of these inconsistencies are a disconnect between water quality standards and application rules for manure and pesticides, the issue of scale for evaluation, side effects of land use subsidies and incentives on water quality and the role of hydrogeology and geochemistry in the effects of land use policy (Platjouw et al., 2019). Earlier studies confirm that existing legal frameworks are insufficient to adequately protect drinking water resources from agricultural pollution (Keessen et al., 2011; Doody et al., 2012; Duncan et al., 2014; Jacobsen et al., 2017). For instance, the allocation of roles and responsibilities differs between directives which means cross-sectoral collaborations take place across different institutional levels. Some of these differences can be explained by the evolution of EU legislation over time, caused by a greater understanding of water systems and societal and economic developments. The more explicit role of the subsidiarity principle in the WFD means that decision-making on waterbody-specific objectives and measures takes place at regional or local level, whereas implementation of the ND primarily takes place at national level (Kastens and Newig 2007; Hüesker and Moss 2015; Van Rijswick and Keessen 2017).

4.2. Coherence of cross-sectoral connections at different levels

The collaboration tools reported primarily focus on the national or river (sub)basin level. In the countries studied, river basin management committees and sub-basin committees are reported to be successful bridging mechanisms between different sectors although the involvement of different sectors (e.g. agriculture, retail) can be difficult.

Multi-sectoral conferences and workshops, inter-agency programming for specific issues, information sharing with the agri-food-industry and guidance on best practices came forward as successful instruments for horizontal collaboration. Yet they all focus on the national or river basin level. At local or regional level, competing interests between different sectors manifest themselves more explicitly, while decisions need to be made on actual measures at these local scales. Similar experiences regarding collaboration at different levels and scales have been described for other countries or regions (Andersson et al., 2012; Blackstock et al., 2014).

4.3. Mode of implementation and attainment of objectives at local level

Individual countries have opted for their own strategies to facilitate the implementation of EU directives across levels and scales. Various authors describe the differences in the mode of implementation between countries and the effects this may have on achieving policy objectives (Keessen et al., 2010; Giakoumis and Voulvoulis 2018). These studies

Table 3
Summary of results for the criteria coherence, consistency and the attainment of objectives at the local level, structured by the principles of the OECD framework (OECD, 2015b).

Dimensions and Principles Analytical framework (OECD, 2015b)		Consistency of EU regulation	Coherence across sectors and levels	Mode of implementation and attainment objectives at local level
Effectiveness	Capacity	Authorities mostly have the capacity to lead, monitor and evaluate. Others lack staff. Finance is reported frequently as an obstacle at different levels.		Several governance measures have been adopted to build capacity to deliver water policy measures, such as public-private collaboration.
	Policy coherence		Instruments reported for policy coherence relevant to horizontal collaboration include multi-sectoral, transboundary, interdisciplinary conferences, inter-agency programmes for specific issues, information sharing with the agri-food-industry and guidance on best practices.	Limited vertical coordination across different levels of governance for several countries is reported because of the fragmentation of policies, disconnected bottom-up and top-down initiatives and data-protection at farm level.
	Appropriate scales within basin systems	EU directives are implemented on a sector-by-sector basis. Good collaboration reported at national level. Cross-sectoral collaboration can be more difficult at the lower levels. Scale is not considered a major issue for effectiveness.	Similar to consistency of EU regulations, the issue of scale not regarded as a major issue for coherence in the different countries studied. The involvement of different sectors is considered to be more relevant.	All countries use management instruments to support drinking water pollution control across scales, yet strategies differ. E.g. advice, participation, protection zones, special programmes.
	Clear roles and responsibilities	All countries have transposed EU directives into national law. All countries identify clear roles and responsibilities at national level for the planning stage. Less clarity exists at lower levels and during the realisation of policy objectives.	Collaboration tools for policy coherence focus on national or river basin level, although there are exceptions. Obstacles reported: competing interests across levels and sectors, access to data, limited decision-making powers, lack of staff.	
Efficiency	Regulatory frameworks in place and enforced		Regulatory frameworks and enforcement play an important role in achieving jointly agreed policy objectives. Different views exist on the balance between voluntary and legal based measures.	Strong variation between countries on the role of legally-based measures and enforcement. Some countries have more voluntary based measures and yet have realised objectives at local level. Other interests, from farmers or other stakeholder groups may, therefore, play a more important role.
	Data and information			Measures are based on knowledge of issues, effects and possibilities of legal framework. Some voluntary measures are less linked to water quality improvement and may be linked to economic motivations as well.
Trust and Engagement	Trade-offs across users, areas, and generations			For countries that rely on voluntary based measures, the selection of measures is usually a balanced trade-off of costs and benefits for farmers. There is, however, little focus across generations.
	Stakeholder engagement	Stakeholder interactions do not occur at all levels. Motivations for engagement or not are: established networks, means and power to act, group size and costs. MAPs are a new way of engagement for some countries.		
	Integrity and Transparency		Conflict prevention and resolution are addressed in different ways. Legal procedures are seldom used, as it is difficult to prove an offence has been committed.	

however, have often taken a sectoral perspective rather than a systemic one.

Most of the instruments reported in this study can also be characterised as sectoral approaches that originated from individual directives which developed along parallel tracks. This implies that, at local level, these sectoral approaches have to all be put into practice together in order to achieve coherency and to be effective in the achievement of water quality objectives. This observation suggests that conditions of governance regarding, for instance, capacity, authority, instruments and means for all sectors at stake, need to be in place at local level if this is to be achieved (Wuijts et al., 2017). For several countries, a lack of funding for local collaboration was reported as one of the obstacles.

For the countries studied, the designation of safeguard zones around drinking water resources was frequently mentioned as a successful instrument for protection, yet requires coherence in the implementation of the different relevant directives in most of the countries studied. How this coherence could be achieved might be different for different institutional levels. Buijze (2015) concludes that generic rules do not function well under all circumstances, and at all levels and scales, whereas instrumental rules are not necessarily problematic and sometimes essential, for instance, in the allocation of roles and responsibilities. Citizen engagement was reported by several countries as an important driver for environmental protection policy.

4.4. Reflections on the analysis

The case studies used for this research focus on water quality issues raised by the use of nitrates and pesticides originating from agricultural emissions and leaching. However, emerging contaminants from agricultural practices (e.g. veterinary pharmaceuticals, antibiotic resistant bacteria, zoonoses) are relevant threats to the quality of drinking water resources as well. To include these in the analysis would require an additional assessment of other EU Directives such as the Community Code relating to veterinary medicinal products (2001/82/EC) and

related directives. This could be an interesting avenue for future research.

The analytical framework used for this study (OECD, 2015b) facilitates an understanding of the strengths and weaknesses of a governance approach. The framework identifies twelve principles within three dimensions, i.e. effectiveness, efficiency and trust and engagement (see Table 2). The structure of the framework suggests that there is a clear division between the three dimensions which would allow for a separate analysis of the principles related to one dimension. As the central question for our study was to explore the effectiveness of EU regulations on the local restoration and protection of drinking water resources from agricultural pollution, our initial proposition was to study the principles related to the 'effectiveness'-dimension. However, the initial data showed that the interlinked principles from the other dimensions had to be taken into account as well. For this reason, the questionnaires were followed up by interviews where additional questions focusing on these other principles were put. The questionnaires developed for this study may also be used to offer guidance on the use of the framework.

The methodology used for data collection involves the risk of a potential bias in the results. Information not provided by an interviewee could be lacking in the analysis. The checks and balances included in the process of data analysis proved to be of added-value in increasing the quality of the data. Scientific literature to date has only described a few examples of local-regional experiences, but other, more sectoral studies on national implementation (Kastens and Newig 2007; Keessen et al., 2011; Voulvoulis et al., 2017), show similarities in the results from the questions on national implementation. The results provide an impression of experiences gained on the protection of drinking water resources from agricultural pollution throughout Europe. These insights could be established in greater detail if complementary case studies were made.

5. Conclusions

This study aimed to identify lessons that could be learnt regarding the coherence and consistency of European legislation to protect drinking water resources from agricultural pollution at local level. The results show that the complexities and inconsistencies of European legislation become most explicit at local level where cross-sectoral measures have to be taken and effects monitored. There they hamper the achievement of water quality objectives. The upcoming revision of the WFD should strengthen the links between the different directives and their objectives in this field and reduce inconsistencies.

Case studies examined in this article show that, as implementation often takes place along parallel tracks, cross-sectoral connections between water policy and other policy domains (e.g. energy, agriculture, nature) often need to be achieved at regional or local level. But it is at this level where a lack of knowledge on the legislative framework, the complexity of water system's responses and the role of different, and often competing interests, block the formation of such connections.

In some case studies there is a plethora of arrangements at farm level that cannot be (directly) linked to national and EU legislation. A more facilitated cross-sectoral approach to policy application at local level should be adopted to improve stakeholder networks, and between institutional levels and hydrological scales, so that higher effectiveness could be achieved.

Author-contribution

Susanne Wuijts, Conceptualization, Methodology, Analysis, Writing - Original Draft, Visualization, Supervision. Jacqueline Claessens-Methodology, Analysis, Writing - Original Draft. Luke Farrow, Validation, Writing - Original Draft - cases. Donnacha G Doody, Validation; Writing - Original Draft - cases. Susanne Klages-Validation; Writing - Original Draft – cases. Chris Christophoridis-Validation; Writing - Original Draft - cases. Rozalija Cvejić-Validation; Writing - Review & Editing. Matjaž Glavan-Writing - Review & Editing. Ingrid Nesheim-Validation; Writing - Review & Editing. Froukje Platjouw-Conceptualization; Writing - Review & Editing. Isobel Wright-Conceptualization; Validation; Writing - Review & Editing. Jenny Rowbottom-Conceptualization; Validation; Writing - Review & Editing. Morten Graversgaard-Validation; Writing - Review & Editing. Cors van den Brink-Validation; Writing - Review & Editing. Inês Leitão-Validation; Writing - Review & Editing. António Ferreira-Writing - Review & Editing. Sandra Boekhold-Conceptualization; Writing - Review & Editing; Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was carried out under the H2020 Fairway project, funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 727984. Fairway aims to review approaches to the protection of drinking water resources from pollution by pesticides and nitrate, and to identify and further develop innovative measures and governance approaches to facilitate more effective drinking water protection (www.fairway-project.eu). We would like to thank Nicolas Surdyk, Linda Tendler, Konstantinos Fytianos and Irina Calciu for the contribution they made by checking the data provided by their respective countries for this analysis.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2021.112270.

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