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Towards Sustainable European Agriculture? Assessing the EU's Progress in Limiting the Negative Ecological Effects of Agriculture on Aquatic Environments

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Abstract: The degradation of terrestrial and aquatic environments has significant adverse effects on biodiversity and environmental sustainability. The ever-increasing population and constant economic growth strain various ecosystems' resistance and resilience. An important factor that negatively influences terrestrial and aquatic ecosystems is the use of products used in crop management. In this article, we analyze the pesticide-related European Directives and the Nationals Action Plans (NAP) regarding the sustainable use of pesticides and other documents evaluating the NAPs implementation. We assess the first and second-generation NAPs of nine EU Member States (MS)' to evaluate if we can identify a significant shift in managing the adverse effects of pesticide use on aquatic environments. Furthermore, we evaluate the degree to which these NAPs are synergic with the EU's strategic approach to soil protection, aquatic environments, and biodiversity.

Keywords: pesticides; biodiversity; aquatic environment; European Union; Sustainable Use Directive; National Action Plan

Citation: Helepciuc, F.-E.; Todor, A.; Bîrsan, C.-C.; Mitoi, M.-E. Towards Sustainable European Agriculture? Assessing the EU's Progress in Limiting the Negative Ecological Effects of Agriculture on Aquatic Environments. *Diversity* **2023**, *15*, 509. https://doi.org/10.3390/d15040509

Academic Editors: Renato de Almeida Sarmento, Vanessa Menezes Oliveira and Miguel Ferrer

Received: 30 December 2022
Revised: 13 March 2023
Accepted: 29 March 2023
Published: 2 April 2023

1. Introduction

The divergent goals of protecting the environment for limiting biodiversity loss and the continuous need to expand agricultural land and improve agriculture's productivity need an ever-more comprehensive approach to balance them. One of the causes of diminishing biodiversity is excessive pollution. Current agricultural practices depend on products intended to increase productivity, such as fertilizers and chemical pesticides, which contribute significantly to the pollution of aquatic and terrestrial ecosystems. One of the main problems in polluted aquatic ecosystems is the agrochemical effect on non-target organisms [1–4]. Furthermore, the pollution of aquatic ecosystems affects the organisms' reproductive cycle of aquatic organisms and their chances for survival.

We will show that limiting the harmful effects of agricultural practices on aquatic and terrestrial ecosystems has gained importance over the last three decades and has been addressed in various normative acts over time in the EU.

Although not referring specifically to the influence of agriculture on aquatic ecosystems, these efforts to limit the effect of agrochemicals on the environment accelerated after the Convention on Biological Diversity adoption in 1992 [1], which inspired efforts worldwide to prevent biodiversity loss [5]. A significant step in these efforts came with the 2010 10th conference of the parties in Nagoya, which led to the Strategic Plan for Biodiversity 2011–2020 (Aichi Biodiversity Targets) [6], requiring to achieve sustainability of agriculture and to decrease the harmful effects of substances used in agriculture (Strategic Goal B, Target 7 requires sustainable management of areas under agriculture, aquaculture, and forestry 2020). The December 2022 UN Biodiversity Conference COP15 struck the Kunming–Montreal pact aiming to protect 30% of the planet's territory by 2030, restore at

least 30% of degraded ecosystems, and limit the negative effects of pesticides [7]. In the European Union (EU), the aforementioned efforts lead to the Natura 2000 program and the adoption of its Biodiversity Strategy [8], among others.

In this article, we start from the assumption that achieving the goal of diminishing the negative ecological effects of agriculture on the aquatic environment can be accomplished only by integrating these efforts into changing the functional pattern of agricultural practices, especially the use of pesticides. As such, we will start our analysis by identifying the essential strategic evolutions in the EU's approach to protecting soil, water, and biodiversity. Subsequently, we will analyze the EU's efforts to reach systematic sustainability of its agriculture materialized in the 'pesticide package' in 2009 containing four legislative acts [9–11], among which Directive 2009/128/EC Sustainable Use Directive (SUD) [12] was the most complex. The SUD also demanded that the EU Member States (MS) explain their activities towards achieving SUD goals to minimize agriculture's adverse effects on aquatic and other environments in National Action Plans (NAPs). This analysis allows us to evaluate the degree to which the EU's goal to limit biodiversity loss caused by agricultural pollution is efficiently integrating the EU legislation and EU MS NAPs to increase the sustainability of their agriculture.

This article is structured as follows. In the Material and Methods section, we present our methodological approach to evaluating the National Action Plan of nine EU MS and how the analysis builds on previous analyses. In the continuation of the Introduction, at the start of the Results and Discussion, we will analyze the goals set in the EU's Strategy for biodiversity on limiting the negative effects of pesticide use on aquatic environments and other relevant legislative pieces covering water policy and soil degradation. Then, we will briefly present the SUD's take on these matters. Subsequently, we present the synthetic results of evaluating the NAPs. In the Conclusions, we summarize the main findings of this comparative analysis and discuss the positive and negative findings. We also summarize the main points of the articles and discuss some avenues to improve the synergies between the EU's efforts to improve the sustainability of its agriculture and its effort to limit the negative effects of pesticide use on aquatic environments.

2. Material and Methods

To understand the degree to which EU MS's approach to implementing the measures aimed at reducing the harm caused by chemical pesticides on aquatic environments, we analyze the first- and second-generation NAPs of nine EU MS (Denmark, Austria, Greece, France, Sweden, Spain, Romania, Hungary, and Poland) with relevant agricultural sectors. We covered countries that joined the EU in different stages from all geographical and climatic evaluation zones (Northern, Central, and Southern). We start to form the assumption that the NAPs represent the best-case scenario of what each EU MS would manage to achieve.

This article builds on previous articles focusing on various aspects of the EU's policy developments in pesticide usage and employing the evaluation of EU MS' NAPs along different dimensions [13–15]. While previously we compared how different EU MS planned their action regarding risk reduction, risk indicators, and impact reduction on humans, in this article, we focus on measuring how NAPs integrate the approach to limit the negative effects of pesticide use on aquatic environments and their synergies with EU's approach on protecting biodiversity, water policy, and soil protection. We read all NAPs and used keywords to identify measures, timetables, and indicators (an approach used in the other articles, too) relevant to limiting the negative effects of chemical pesticides on aquatic environments.

3. Results and Discussion

To adequately evaluate EU MS's recent efforts relevant to protecting aquatic environments, we have to evaluate them within the strategies for limiting water and soil pollution and the protection of biodiversity. The 2000 EU's framework in the field of water policy

made just some reference to agriculture's polluting effects on sources of water [16]. Instead, the 2006 Directive 2006/118/EC of the European Parliament and of the Council on the protection of groundwater against pollution and deterioration [17] introduced the maximum concentration accepted for nitrates and active substances in pesticides, including their relevant metabolites, degradation and reaction products. Furthermore, with Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy [18], the detailed environmental quality standards have been updated, including for pesticides.

The 2006 Thematic Strategy for Soil Protection [19] stated that agricultural practices could positively affect the state of soil but also ranked inadequate agricultural and forestry practices as important sources of soil degradation. It also underlined the deleterious effects of soil degradation on water and air quality, biodiversity, and climate change. EC was asked to integrate soil protection measures in the good agricultural and environmental conditions requirements defined in Regulation 1782/2003. Subsequently, a 2012 report from the EC on the implementation of the EU' s Soil Thematic Strategy noticed that soil erosion also increases the pollution of freshwaters as it increases the transfer of nutrients and pesticides [20].

Directive 2009/128/EC of 21 October 2009, establishing a framework for community action to achieve the sustainable use of pesticides [12], recognized the aquatic environment's sensitivity to pesticides. Avoiding pollution of surface and groundwater required measures such as "the establishment of buffer and safeguard zones or planting hedges along surface waters to reduce exposure of water bodies to spray drift, drain flow, and run-off...." (point 15). It also demanded avoiding pesticide use in drinking water abstraction along transport routes, permeable surfaces, Natura 2000 sites, and other public areas. The directive required each EU MS to elaborate National Action Plans "to set up their quantitative objectives, targets, measures, and timetables to reduce risks and impacts of pesticide use on human health and the environment and to encourage the development and introduction of integrated pest management and of alternative approaches or techniques to reduce dependency on the use of pesticides." It also contained provisions on training for pesticide application, especially aerial spraying, requirements for sales of pesticides, information and awareness-raising, and inspection of equipment in use, information to the public (Art 10), reduction of pesticide use or risks in specific areas (Art 12), handling, and storage of pesticides and treatment of their packaging and remnants (Art 13). Additionally, Article 11 was dedicated to specific measures to protect the aquatic environment and drinking water.

One key conclusion of these previous assessments of the implementation of the NAP is that the second-generation NAPs do not contain evaluations of the achievements of the first-generation NAPs and, thus, contain no indication that they are built on the lessons learned. The quality of operationalization of the measures proposed in SUD varies widely in the NAPs of different EU MS. The limited success in achieving SUD's second and third goals, promotion of integrated pest management (IPM) and low-risk alternatives to chemical pesticides were particularly problematic across most EU MS. Despite explicitly proposing some goals, EU MS might not be willing to take concrete actions towards achieving them.

EU's Biodiversity Strategy [8] recognized pollution as a key driver of biodiversity loss and listed the release of nutrients and chemical pesticides as the top sources. It also stresses the importance of the Farm to Fork Strategy's [21] goal to reduce the use and risk coming from chemical pesticides by 2030, decreasing use by 50% of the most hazardous pesticides by 2030, as well as the aim to promote the adoption of IPM. The 2020 Farm to Fork Strategy stressed that despite progress in the sustainability of the EU's food system, it remained one of the key drivers of climate change, environmental degradation, and biodiversity loss. The strategy also noticed the 20% progress in risk reduction assessed by the Harmonized Risk Indicator between 2015 and 2020 and the commitment to mitigate risks by 50% by 2030.

Furthermore, the 2021's European Parliament (EP) resolution on soil protection [22] recognized that "agricultural intensification and overuse of pesticides are causing soil

contamination by pesticide residues . . . " (point AG) and requested more measures on monitoring pesticides residues (no. 32). Additionally, it asked concrete measures from the EC to tackle contamination of soil and aquatic environments caused by farming activities (no. 40). Another European Parliament's resolution on the 15th meeting of the Conference of Parties (COP15) to the Convention on Biological Diversity [23] also stressed the need for immediate action in these areas. Overall, as these strategic and legislative pieces have also been implemented or transposed at the national level, they should directly influence the measures proposed in the NAPs of each EU MS and create a synergic approach towards these goals. In the remainder of this section, we will synthetically present the results of analyzing the first and second generation of NAPs of nine EU MS.

Denmark adopted the Pesticide Load Index (PLI), which is used as an advancement to the Treatment Frequency Indices developed in 2008. The PLI is defined as the amount of the applied product multiplied by the toxicity to non-target organisms. Pesticide loads are calculated for human health, environmental toxicity, and environmental behavior. According to the evaluation presented in the first NAP, 2013–2015 [24], from 2007 until 2011, the pesticide load (PLI) increased by 35%, from 2.48 to 3.35. As such, the NAP proposed the goal of reducing the pesticide load by 40% by the end of 2015 compared with 2011. The 2013 NAP also proposed a focus on pesticide reduction by implementing integrated pest management (IPM) and a series of other benchmarks, such as decreasing health loads from using substances of serious concern or decreasing pesticide residues in food. The 2012 NAP contains a dedicated benchmark to achieve "no transgression of pesticide thresholds values in the groundwater" (pp. 32) by implementing an international review of the approval scheme, increasing knowledge, strengthening collaboration in managing point-source pollution, strengthening international cooperation, communication with citizens, and research efforts.

Denmark's second generation NAP, 2017–2021 [25], builds on the Pesticides Strategy 2013–2016. Among other goals, the NAP aimed to protect drinking water wells and limit pesticide use in protected zones and golf courses. The NAP also notes progress in monitoring groundwater but makes no specific references to the diminishing effects of pesticide use on the aquatic environment.

Austria's 2012 NAP [26] is divided into nine parts (Land Action Plans—LAPs), each for the nine states. Although they have more or less the same structure, the content of the LAPs differs among the provinces. Austria's NAP mentions that Plant Protection Products (PPP) use is extensively regulated at the national level. A legislative act regarding the use of plant protection products (Plant Protection Product Act, 2011) was adopted in 2011, before the deadline for NAPs communication. Technical measures proposed are mostly vaguely described, with some examples of measures ("loss-minimizing application, e.g., tunnel spray machines in orchards and vineyards"). According to the 2012 NAP, although aerial spraying is not usual in Austria, article 9 of the SUD is transposed in three provinces' PPP Act. However, no timetables are set, and no indicators are presented. No indicators were calculated.

Austria's 2017 NAP [27] is a uniform act conceived by the joint effort of the representatives of each province and other interested parties. The articles of the SUD are treated individually, each section containing background information, further steps, and quantifiable objectives, targets, and timetables. The measures proposed by Austria regarding the limitation of negative effects of the PPPs on aquatic environments refer to the advice offered in agricultural practices (appropriate plant protection measures, crop rotation, etc.), information concerning the specifications of PPPs (active substance), establishing limitations where necessary and inspections, and adopting restrictions in sensitive areas. Authorization requires protective measures for the aquatic environment and drinking water, such as maintaining the minimum distance from surface waters. The authorization also specifies if the product use is banned in water protection or conservation areas. However, the objectives are very generally described. Moreover, with few exceptions, no targets and timetables are set.

In the case of surface waters, environmental quality standards (EQS) are set by the "Quality Targets (chemicals in surface waters) Regulation". The upper accepted concentration for groundwater/drinking water is "as a rule 0.1 ug/L"; if that limit is exceeded, the area becomes an observation zone or prospective action zone.

The 2013 Greece NAP [28] approaches all SUD articles as separate chapters. Some measures for aquatic environment protection are presented. Monitoring the chemical composition of groundwater and surface water is conducted by two institutions Ministry of Rural Development and Food, and the Special Water Secretary of the Ministry of Environment, Energy, and Climate Change conducts controls through the National Control Net.

The professional users are informed regarding the advantages of low-drift nozzle use (through The Agricultural Warnings system) and about risk reduction measures by the Coordination National Authority (CNA). The same institution is responsible for the setting up of procedures for the following measures: priority use of PPPs that are not included in the category of priority dangerous substances, choosing the most effective PPP application techniques, as the use of low-drift equipment in orchards and vineyards, minimizing the non-targeted area's pollution which can be caused by "spray drift, drain-flow, and run-off," and minimizing or total interruption of PPP application close to surface and groundwater. The procedures are not detailed, and for most of them, no calendar or quantifiable targets are set.

Two of Greece's four General National Indicators measure PPPs' effects on the aquatic environment. Greece proposes a 10% reduction of the "percentage of Maximum Residue Limits exceedances about the total number of samples" by 2015 and a 5% increase in low drift nozzles use yearly. The Specific National Indicators include environmental quality assessment "using behavioral pesticide statistical models for the environment and the prediction of pollution levels caused by pesticide use up to the farm level and to the linkage basins level, as well as to the chemical definition of pollution levels and bioassays in samples taken from different country regions."

The 2020 NAP [29] is quite similar to the first one regarding the effects of PPPs on the aquatic environment proposing an additional set of measures. The CAN indicator evaluates the information regarding PPPs sales and the results of groundwater and surface water analyses and should suggest limiting or prohibiting active substances in certain areas and including some PPPs in the country's current monitoring program. The 2020 NAO proposes the yearly reduction of Harmonised Risk Indicator 2 by 2.5%. Two other indicators refer to an increase of low-risk PPPs use by 5% each year and PPP containing macroorganisms by 2% each year. Another target is to reduce exceeding the maximum allowable residue level by 2% each year.

Spain's 2012 NAP [30] contains seven specific objectives that do not follow the SUD articles. However, almost all aspects regarding the effects of PPP on the environment mentioned in SUD are covered, and 4–8 objective-specific measures support each objective, and for each measure the existing situation and indicators are indicated.

The 2017 NAP [31] is reorganized into nine specific objectives, the new objectives approaching improved verification for PPP use and improved and extended PPP use alerts for citizens. Additionally, new important objective-specific measures were introduced (1.2 Improve knowledge of plant protection products available for non-agricultural uses; 6.1 Promote systems for the withdrawal from use of plant protection products and remnants thereof; 6.5 Set up programs to monitor the presence of plant protection products in surface and ground waters). For some objective-specific measures, quantitative targets are set (6.2 Promote empty container collection system; 6.4 Improve monitoring of the marketing of plant protection products). The second NAP also contains a section on the annual reports evaluation content but no measure-specific indicators. Water quality monitoring focuses on a monthly or quarterly sampling of contaminants according to the substance classification (priority or preferential). Groundwater quality is tested at least once a year. Although some compliance indicators are set, no use or risk reduction indicators are presented.

The 2013 Sweden NAP [32] is structured around five general objectives, three directly involved in limiting the effects of agriculture on the environment: the overall objective regarding risk reduction, residues in surface water, groundwater, and drinking water, and developing a sustainable cultivation system. In the 2013 NAP of Sweden, all SUD nails are approached, and measures are discussed in the context of the directive's articles. The specific measures aimed at minimizing the deleterious effects of PPPs on the aquatic ecosystem are elaborated into detail and operationalized. For PPPs in surface water, Sweden uses guide values for the "no observed effect concentration" but proposes no timetables for the measures.

Sweden had been using two national risk indicators, the risk index for health and the environment and the toxicity index, long before the adoption of the SUD. Sweden has also monitored different activities relevant to PPP use reduction and implicitly for mitigating their environmental effects (the amount of non-chemically treated seeds, etc.). Statistics regarding the amount of PPPs sold and used are also available. Sweden established a list of three active substances to identify their use trends (pendimethalin—due to its bioaccumulative and persistent properties, it should be gradually excluded within a generation; bentazon (Annex III, Directive 105/2008); and pyrethroids were found in high concentrations (up to 50 times higher than guide values) in surface water).

Sweden's second NAP (2019–2022) [33] contains an evaluation of the 2013–2017 NAP. Sweden maintains the five objectives and, based on the previous NAP evaluation, introduces the sixth one regarding the use of harmful PPPs for pollinating insects. In this NAP, Sweden establishes clear limits and timetables for the second objective, regarding reducing PPP residues in surface water and groundwater. The same two national risk indicators are mentioned in the second NAP. The list of substances for trend use identification reaches five active substances and the neonicotinoids class, the last known to affect pollinators, mainly wild bees, negatively. Sweden also proposes a set of good practices for PPPs use to help achieve the Directive's purposes for use reduction.

France elaborated a plan for PPP use reduction in 2008 [34], before the SUD adoption. The plan has eight focuses, with the core focus of PPP use reduction (by 50% in 10 years) accompanied by the safe use of pesticides, improving the monitoring of negative effects of pesticides on the environment, and safe and reduced use in non-agricultural areas. Measures concerning the aquatic environment and drinking water protection are based mainly on elaborating a unitary reliable monitoring system of PPPs use and their effects across the country.

France's second NAP [35] is also based on massive (considerable) pesticide use reduction. First, France aims for a 25% reduction by 2020, achieved by techniques optimization, and second, a 50% reduction by 2025, achieved by a complex set of measures involving changes in a production system, policy determinants, and scientific and technical progress. The use reduction evaluation will be made using clear indicators to determine the quantities applied, the number and frequency of the treatments, the impact, the risks involved, and practice improvement. Specific measures regarding the impact of PPPs on the environment refer to stimulating multidisciplinary research, improving water, soil, and air contamination monitoring, and using improved indicators.

France has three categories of indicators: use indicators, impact indicators, and changing practice indicators. France proposed to establish an eco-toxicology indicator regarding PPP's environmental impact (by 31 December 2105) with immediate availability. Three other indicators used by France are unit dose number (NODU), active substance quantity (QSA), and treatment frequency index (IFT). The first two indicators should be used depending on the type of PPP used and on the targeted pest.

In Romania, in the first NAP from 2013 [36], three main areas of measures are proposed regarding the use of PPP with effects on health, the competitiveness of the Romanian agricultural sector but also on environmental protection with a focus on the protection of waters, biodiversity, and soil. Mitigating the risk of contaminating the soil, the air, surface water, and groundwater is one of the specific objectives, and a series of nine

measures are proposed to overcome this risk. In accordance with the requirements of the SUD, measure 3 of Romania's NAP aims to promote multifunctional protection areas, especially for agricultural areas on slopes and close to surface waters (measures for the interval 2013–2015). These measures promoted good practices for avoiding pollution from intermittent and diffuse sources, the technologies for reducing the drift of sprayed products, and the existence of multifunctional protection in agricultural areas close to surface waters. Compliance with legal provisions for establishing and protecting specific areas, storing and managing waste and empty packaging of PPP, and certification of application equipment is compulsory. Optimization of the used PPP by prognosis and warning system, reduction of the impact on pollinating insects, and communication and awareness programs were also proposed. Indicators, quantitative targets, responsible authority, and deadlines are defined only for four of these measures [37].

Hungary's first NAP was adopted in 2012 [38]. It explicitly acknowledges the link between chemical pesticides and the quality of aquatic ecosystems and is built in synergy with Directive 2006/118/EC on the protection of groundwater against pollution and deterioration and Directive 2000/60/EC on the Water Framework Directive (WFD). It contains an evaluation of the evolution of the situation since 1954 and the environmental protection measures over the years. The implication of pesticide usage in various situations affecting water and aquatic environments is discussed. Additionally, aerial spraying is tightly controlled, and relevant indicators are proposed as well as indicators designed to limit the impact of pesticides application on water (prevention of point pollution of soil and water during work) and aquatic environments (reduction of environmental loading, particularly the protection of sub-surface waters, surface waters, soils; see p. 36).

In the updated version of the second NAP of 2019 [39], references to the legislation in force are more frequent, and the protection of aquatic ecosystems is assumed as a core goal. Most laws referred to previous legislation to the first NAP, and only three normative acts were approved after the first NAP. Reducing the contamination risk of water, soil, and air appears in the objectives, but the measures strictly referred to the multifunctional protection zones as the major component of the ecosystems and the reduction of the drift effect. The indicators refer to the number of informed persons and checks per year. Monitoring covers only these protected areas, but no details are offered. Most other measures stipulated in the first NAP can be found as specific objectives, not as measures to overcome the risks of using PPP on the environment.

The current Hungarian NAP (2019–2023) assumes in measure 5.3.1 the objective of protecting aquatic organisms. It provides a series of measures that refer to counteracting the effects of PPP use on the environment and that include five directions: protection of drinking water abstraction areas, prohibition/restriction of PPP use in sensitive areas, reduction of PPP waste and packaging materials, reducing the risks associated with the improper use of PPP application equipment, and protection of bees and other pollination insects. Although not without imagination, the proposed measures are vague and without concrete targets, and the predicted indicators are expressed as a ratio from the total, without quantitative estimates and execution times. Additionally, the references to the legislation in force are very limited. If the current version of the NAP lacks concrete measures to overcome the risks determined by using PPP, the first NAP is an impoverished version of it.

In the case of Poland, the first NAP from 2013 [40] provided a set of nine measures, each with specific actions to combat the risks associated with using PPP for human, animal, and environmental health. There were no strictly defined measures or actions aimed at the effects on the aquatic or terrestrial environment. The second NAP from 2018 [41] proposes action 7 with detailed measures to protect the aquatic environment and drinking water. In general, monitoring and analysis tasks are defined within these actions. Measure 7 describes the relevant existing legislation, the measures for monitoring of surface waters and groundwater and of bottom sediments (surface waters, groundwater, and bottom sediments) (Task 1), analyses of the impact of chemical plant protection on the state of

surface waters (Task 3), and supervision over plant protection products containing active substances that should be subject to specific monitoring (Task 4). The types of analyses through which these monitorings are carried out and who is responsible are very clearly specified, but no quantitative targets and no timetable are foreseen. Polish NAPs are very well in line with the national legislation in force, but they also refer to many normative acts of the European Commission. Additionally, action 8 proposes to limit the use of PPP in particularly sensitive areas.

All in all, the recent report Sustainable use of plant protection products: limited progress in measuring and reducing risks [42] by the European Court of Auditors shows that the limited enforcement of the SUD directive and the lack of conditionality of the funds offered through the Common Agricultural Policy with progress in implementing practices designed to minimize the use and risks of pesticides hinders progress in this area. Our recent comparative evaluation of EU MS's NAPs [14] showed that the absence of a systematic structuring of measures, timetables, and measure-level indicators generates difficulties in allowing best practices to be transferred and progress toward reducing both risks and the use of chemical pesticides.

The 2019 first publication of Harmonized Risk Indicator 1 (HRI 1), defined as a decrease in the use and risk of pesticides, showed a 17% decrease at the EU level [43]. Nevertheless, a recent European Economic and Social Committee report shows the limited amount of data this indicator is based on [44]. Additionally, despite comprehensive legislation regarding pesticides, between 2011 and 2020, the quantity of pesticides sold in the EU did not register a decrease (around 350,000 tons per year), most of it being used in the agricultural sector [45].

4. Conclusions

As recent evaluations showed that the efforts undertaken in the last decades are far from enough to protect our terrestrial and aquatic environment, efforts to prevent the continuous loss of biodiversity and irreversible deterioration of the environment due to various human activities have to step up. Current agricultural practices, employing intensive use of fertilizers and synthetic pesticides to increase crop productivity, are among the top source of environmental degradation. To understand if the current trends among EU MS are indicative of a significant shift in the right direction, in this article, we have focused on analyzing the agrochemicals related European Directives and the measures focused on protecting aquatic environments in the first and second-generation NAPs (2011–2012 and 2018–2019) of nine EU MS.

Evaluating the evolution of the EU's efforts to develop strategies and operationalize them through legislation aimed at decreasing the negative effect of agricultural practices on the environment, especially in decreasing the negative effects of pesticides, show significant progress. The current analysis reveals that while still perfectible, the way the analyzed countries have operationalized their NAPs is synergic with the EU's approach to limiting the negative effects of agricultural practices on the aquatic environments. Nevertheless, these efforts' efficiency is dependent on EU MS's willingness to operationalize them and go beyond simply meeting some formal criteria to avoid infringement procedures. Although the aspect of limiting the negative effects of PPP on aquatic ecosystems is addressed in most NAPs through the more or less detailed description of measures aimed at reducing the intended effects or through references to the national legislation of each state, concrete measures with targets measurable and the proposal of a calendar for reaching these targets is present only in the NAPs of some countries.

Our focus on structuring measures, timetables, and indicators relevant to reducing the negative effects of chemical pesticide usage on the aquatic environment reveals similar heterogeneity to other directions previously analyzed, such as health risks and IPM. None of the nine countries had treated these measures in a comparable way or with similar indicators. Thus, no comparative assessment of their efforts could be provided. As the legislation on water pollution is already developed in all EU MS, compared to IPM, which is not regulated, we expected the NAPs to propose more measures to protect aquatic

environments from the negative effects of pesticides. Additionally, a measure of the EU's legislation on pesticide use success would have been the reduction of commercialized pesticide quantities, but, however, this is not yet the case.

To evaluate the degree to which the EU MS' NAPs are an efficient policy instrument to achieve the EU Green Deal or the Kunming–Montreal pact requires their assessment through measure-by-measure indicators that would then allow for transparent assessments of each country's success in achieving various targets and would allow for a transfer of best practices. In the absence of a set of homogenous set of measures, indicators, and timetables, such a comparative evaluation is difficult.

Previous experience regarding the effectiveness of achieving the objectives proposed in different EU normative acts shows that it is not enough to set general targets. However, it is necessary to assume specific targets for each measure so that detailed comparison and assessment of progress can be systematically conducted. Such assessments would be necessary to directly approach the main areas that generate delays in achieving appropriate progress in decreasing the effect of agricultural practices on the aquatic environment.

Author Contributions: Conceptualization, A.T. and F.-E.H.; methodology, A.T.; software, A.T.; validation, F.-E.H.; C.-C.B. and M.-E.M.; writing—original draft preparation, A.T., F.-E.H. and C.-C.B. and M.-E.M.; writing—review and editing, A.T. and F.-E.H.; funding acquisition, F.-E.H. All authors have read and agreed to the published version of the manuscript.

Funding: The study was partially funded by project No. RO1567-IBB06/2022 from the Institute of Biology Bucharest of Romanian Academy.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: All the National Action Plans can be downloaded at: https://food.ec.europa.eu/plants/pesticides/sustainable-use-pesticides/national-action-plans_en (accessed on 3 December 2022).

Conflicts of Interest: The authors declare no conflict of interest.

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