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What is the deal with the Green Deal: Will the new strategy help to improve European freshwater quality beyond the Water Framework Directive?

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Abstract

Agricultural land use covers almost half of the EU territory and reducing nutrient and pesticide losses to freshwaters is central to existing EU policy. However, the progress of improving freshwater quality and reducing eutrophication is slow and lags behind targets. The Green Deal is a key element of the EU plans to implement the United Nation's Sustainable Development Goals. Here, we discuss the opportunities that the Green Deal and associated strategies may provide for the achievement of the water quality goals of the Water Framework Directive in agricultural landscapes. We welcome Green Deal's aspirational stated goals. However, the reliance of mitigation of diffuse agricultural pollution on the reform of the Common Agricultural Policy represents grave risks for practical implementation and the achievement of the Green Deal objectives. We also argue that the new strategies should be targeted at tackling and understanding the sources of water quality problems along the full pollution continuum. To maximise the opportunities for tackling diffuse pollution from agricultural land use and achieving the delayed water quality targets, we stress that a range of targeted new instruments will be needed to close the gaps in the pollution continuum 'from source to impact'. These gaps include: (I) smart and standardised monitoring of the impacts of proposed eco-schemes and agri-environment-climate measures, (ii) active restoration of agricultural streams and ditches and their floodplains to reduce secondary pollution sources, (iii) options to draw down nutrient levels to or below the agronomic optimum that reduce legacy sources, (iv) integrating farm-scale and catchment-scale analysis of trade-offs in reducing different pollutants and their combined effects, and finally (v) accounting for emerging pressures to freshwater quality due to climate change. Incorporation of the pollution continuum framework into tackling diffuse agricultural pollution will ensure that the European water-related policy goals are achieved.

Keywords: nutrient losses, Sustainable Development Goals, diffuse pollution, Common Agricultural Policy

1. Introduction

Agricultural land use covers almost half of the EU territory. The sector is responsible for half of the total EU water usage (European Commission, 2017) and reducing agricultural pollution to freshwaters, i.e. nutrient and pesticide losses, is central to existing EU policy (Water Framework, Groundwater, Nitrates, and Sustainable Use of Pesticides Directives). However, despite extensive and intricate regulation, the progress of improving freshwater quality and reducing eutrophication lags behind targets. A recent report (European Environment Agency, 2018) showed that 60% of European water bodies fail to achieve good ecological and good chemical status. The reasons for this slow improvement can be (partly) attributed to the ongoing problems with the implementation of the EUs flagship policy regulating freshwater quality, the Water Framework Directive (WFD) (Carvalho et al., 2019; Voulvoulis et al., 2017). With the onset of a new European research programme, Horizon Europe and the Mission Starfish, a new set of higher ambitions is introduced when it comes to reducing pesticide, nutrient and toxic substance losses to freshwaters. At the same time, the new EU strategies Green Deal and Farm to Fork aim to integrate existing policies, e.g. WFD and Nitrates Directive with wider objectives related to climate change impacts, adaptation and sustainable development goals in an integrated holistic framework. Since the adoption of the Water Framework and Nitrates Directives, scientific evidence has shown that quick fixes to freshwater quality might be elusive due to the intrinsic complexity of freshwater ecosystems and their catchments (Bol et al., 2018). In this opinion piece, we explore whether and how this new policy framework can contribute to improving EU freshwater quality and help to achieve the delayed WFD targets.

2. Freshwater catchment complexity and challenges in reducing agricultural pollution

Reducing nutrient and pesticide losses from agricultural land proves difficult due to complex processes regulating to their transport from land to water (Bieroza et al., 2020). Pollution continuum is a framework capturing this complexity, starting with land sources, mobilisation, delivery to the stream network and finally impact on stream ecology and human health in downstream ecosystems, e.g. lakes, seas and oceans (Haygarth et al., 2005). Since nutrient and pesticide pollution from agriculture is diffuse in nature and spread across the landscape, it is difficult to effectively manage and mitigate. Another complication is that pollution transfers are rarely unidirectional and covering all the steps of the continuum, i.e. from sources to impact. Instead, pollution transfers are spread in time and can be subject to considerable time lags in the catchment systems due to hydrological, biogeochemical and stream network delays (Van Meter and Basu, 2017). As a result, in agricultural landscapes, both the primary (e.g. recent fertiliser applications) and secondary pollution sources (pollutants in transient storage e.g. riparian zone or adsorbed to stream sediments) are present simultaneously and subjected to mobilisation and subsequent re-mobilisation in the stream network (Bol et al., 2018). In catchments suffering from long-term pollution, i.e. intensively managed agricultural catchments, nutrients, pesticides and other pollutants can accumulate in the soils or subsurface over time, creating an abundant legacy source (Bieroza et al., 2019; Haygarth et al., 2014; Powers et al., 2016; Van Meter et al., 2017). The impact of multiple stressors on aquatic ecology is also complex and nonlinear, often showing inertia in communities' responses to multiple acute and chronic pollution pressures (Davis et al., 2018). As a result, it is almost impossible to establish a causal link between ecological impact and the original source of pollution (Birk et al., 2020; Glendell et al., 2019). Therefore, holistic monitoring and management approaches, e.g., simultaneously targeting different types of sources (primary, secondary, and legacy), stressors (nutrients, sediments, pesticides, and other pollutants including micro pollutants) and pressures on freshwaters (eutrophication, erosion, climate change) are needed.

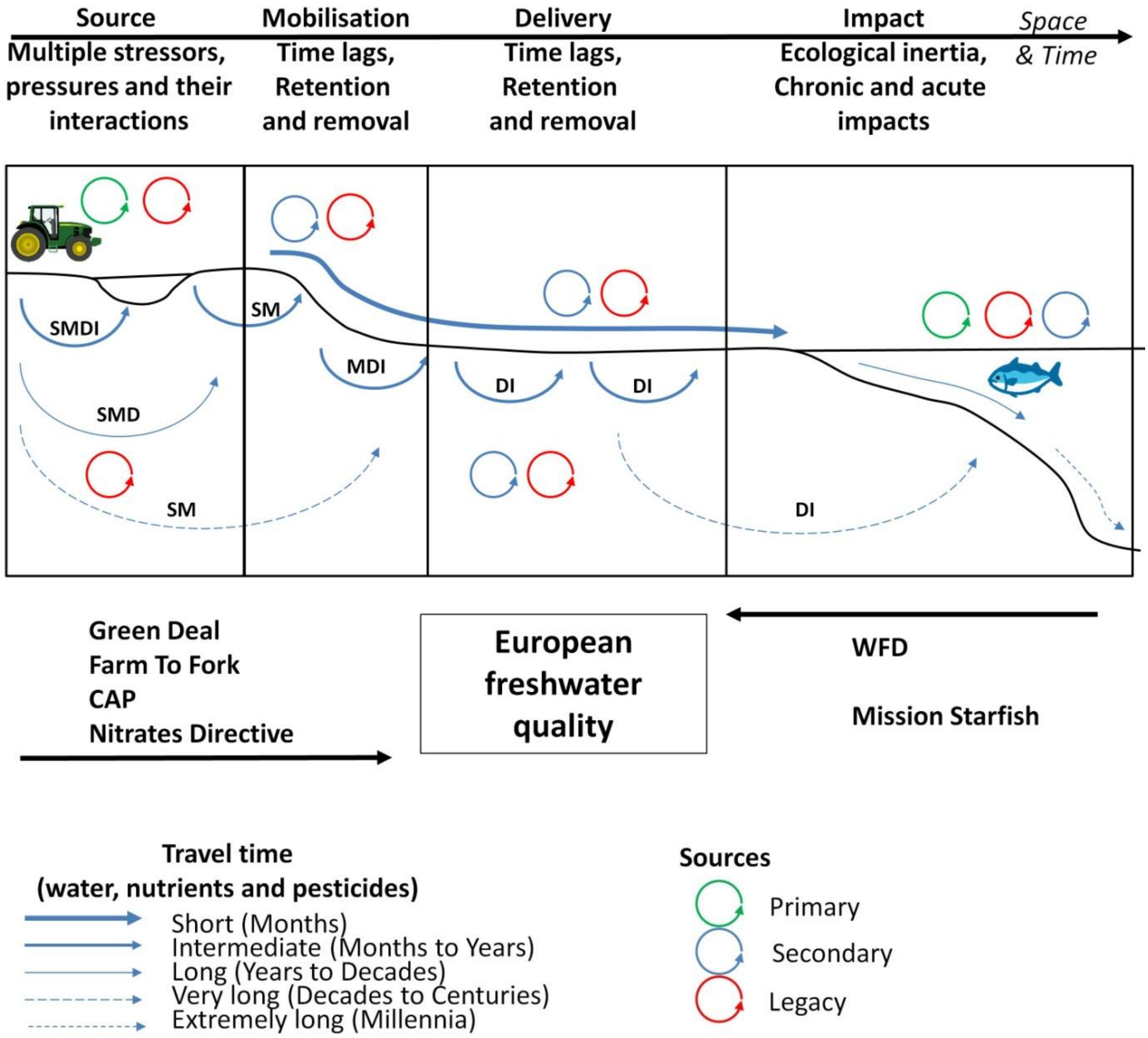

Figure 1 Complexity of the water pollution continuum and European strategies to improving freshwater quality. A conceptual representation of terrestrial water cycle and pollution trajectories of different travel times (denoted by weight of arrows) and extent (denoted by letters indicating S source, M mobilisation, D delivery and I impact). Each continuum step involves complex processes controlling diffuse pollution mobilisation, retention and transfer to the downstream compartment. European freshwater quality is regulated by the WFD (focus on impact) while the new Green Deal, Farm to Fork, CAP and Nitrates Directive are focussed on sources and their mobilisation. Mission Starfish focuses on reducing pollution point sources and restoring ocean ecosystems.

3. Existing strategies: The Water Framework Directive

The Water Framework Directive 2000 (WFD) (European Commission, 2000) is a flagship European environmental policy that has introduced a focus on holistic management of river basins as the natural geographical and hydrological units. However, the Directive's original aim of achieving at least good ecological status for all surface water bodies by 2015 has proved overly challenging to achieve and is currently extended until 2027 (European Environment Agency, 2018). Ecological status is based on biological quality elements (phytoplankton, macrophytes, phytobenthos, benthic invertebrate fauna and fish), together with physico-chemical and hydromorphological quality elements in the case of high status assignment. According to the European Environment Agency (2018), only around 40% of surface waters were in good ecological status or potential, and only 38% were in good chemical status at the time of reporting. Whilst the impact of some mitigation measures may become apparent by the beginning of the third RBMP cycle in 2021 (European Environment Agency, 2018), progress may also be obscured by the requirement of the 'one-out-all-out' principle, whereby the failure of a single assessment element leads to the failure to achieve good status (EarEau, 2018). Hydromorphological pressures (40%) and diffuse pollution from agriculture (38%), are the two most significant causes of failure in surface water bodies, with point sources ranking fourth (18%) and water abstraction fifth (7%). Atmospheric deposition (38%) is mainly linked to pollution of harmful substances, especially mercury (European Environment Agency, 2018). The WFD was introduced to overcome the fragmentation of European water policy, including the provisions of its 'daughter' directives: Urban Waste Water Treatment, Nitrates, Drinking Water, Integrated Pollution and Prevention Control Directives.

Despite the success in setting up a governance framework for integrated water management for over 110,000 EU water bodies and improving their ecological and chemical status, a recent fitness check of the WFD (European Commission, 2019b) has pointed out that its implementation is severely delayed due to insufficient funding, slow implementation by Member States and insufficient integration of environmental objectives in sectoral policies. The WFD target focuses on the final step of the pollution continuum – ecological impact. Based on the ecological and chemical status, dominant pressures should be identified at a basin scale and mitigated through targeted programmes of measures (European Commission, 2000). However, ecological impact is a result of many external and internal controls on the ecological community, including multiple stressors and associated pressures; therefore, understanding and prioritising these controls for management purposes proves difficult. Similar ecological (Davis et al., 2018) or chemical (Vero et al., 2019) status classifications can have different mechanistic explanations, e.g. high summer dissolved phosphorus concentrations may be caused by groundwater inputs, in-stream mobilisation and desorption, or point source inputs, which can be one of the reasons why achieving the WFD goals is proving difficult (Carvalho et al., 2019).

4. New strategies: The Green Deal, Farm to Fork and Mission Starfish

The Green Deal (European Commission, 2019a) is a key element of the EU strategy to implement the United Nation's Sustainable Development Goals (SDGs) (UN General Assembly, 2015) pertinent to reducing air, water and soil pollution, reducing the loss of biodiversity and climate change impact, while ensuring sustainable use of energy and natural resources and well-being of citizens. A key objective of the Green Deal is to provide a holistic policy framework for achieving carbon neutrality by 2050 (European Commission, 2019a). A high level of ambition in the Green Deal to tackle complex and interlinked environmental, economic and societal challenges requires integration of current policies and exploitation of potential synergies and trade-offs. Key priorities for restoring terrestrial and aquatic environments in the Green Deal include designing environmentally friendly food production systems, preserving and restoring ecosystems and their services, including biodiversity and a zero-pollution ambition for a toxic-free environment. Agricultural production is recognised as an important source of air, water and soil pollution, contributing to loss of biodiversity and climate change, and consuming excessive amounts of natural resources. To enable a sustainable transition of agricultural sector and implementation of the goals of the Green Deal, the Farm to Fork (European

Commission, 2020b) strategy has been launched and a revised Common Agricultural Policy (CAP) will be introduced in 2023.

The Farm to Fork (F2F) strategy recognises the negative impact of agricultural production on climate and environment, aiming to improve health of both citizens and environment by a shift to sustainable food systems. The strategy aims to achieve 50% reductions in pesticide and antibiotics use and 50% reduction in nutrient losses by 2030, resulting in at least 20% reduction in fertiliser use (European Commission, 2020b). Each Member State will develop an integrated nutrient management action plan stating what nutrient load reductions are needed to achieve the F2F goals. In addition to reducing agricultural losses, the Commission will propose measures to address pollution from urban runoff and from new or particularly harmful sources of pollution such as micro plastics and chemicals, including pharmaceuticals.

It is envisaged that the goals of the Farm to Fork strategy related to diffuse pollution from agriculture and hence the Green Deal will be delivered through the reformed Common Agricultural Policy (CAP) (European Commission, 2020e). CAP provides a complementary set of voluntary tools offered to farmers, including one-year-at-a-time eco-schemes in Pillar 1 (Table 1) and continuation of the multi-annual agri-environment-climate measures (AECMs) in Pillar 2 (European Commission, 2019c). Eco-schemes offer direct payments as an incentive to farmers to adopt environment and climate friendly practices, unlike AECMs that solely compensate farmers for the costs and income foregone due to adoption of mitigation practices (European Commission, 2019c). The AECMs aim to restore, preserve and enhance ecosystems, including freshwater protection measures such as: establishment of buffer strips along water bodies, management of wetlands and restoration of natural water conditions, cattle fences (UK), state acquisition of land (Denmark), and restoration of agricultural ditches (Swedish Board of Agriculture, 2013). In the new CAP, each Member State will develop a Strategic Plan formulating means to address nine CAP objectives (European Commission, 2021), and will have flexibility in setting the AECMs to either complement or strengthen the obligatory eco-schemes. Additionally, CAP supports environment- and climate-friendly farming practices and standards known as 'Good Agricultural and Environmental Conditions' (GAECs) and Statutory Management Requirements (SMRs). There are two GAECs focused on protecting waters: GAEC 4 – Establishment of buffer strips along watercourses, and GAEC 5 – Compulsory use of the new Farm Sustainability Tool for Nutrients. The SMRs will provide a link to existing EU legislation, e.g. Water Framework, Nitrates, and Sustainable Use of Pesticides Directives by inclusion within the scope of CAP's conditionality, meaning that farmers receiving direct payments will have to comply with the obligations of these directives through compliance with national standards.

The wider goals of the Green Deal will also be supported by EU missions, as an integral part of the Horizon Europe's research programme to combat greatest environmental, societal and health challenges. Specifically, Mission Starfish (European Commission, 2020d) provides a systemic approach to reducing human pressures, including pollution and climate change, on oceans, seas, coastal and inland waters and a significant step towards restoring their ecosystem functions. The Mission includes five objectives and 17 measurable targets to be achieved by 2030 of which freshwater quality is covered by target 3 (30% of EU waters are fully protected), 5 (re-naturalise rivers and waters) and 7-9 (zero plastic litter, zero eutrophication and zero spill). Some specific actions by 2030 include reducing total water abstraction by 50%, including groundwater abstraction by 20%, de-damming of 30% of

Europe's rivers, reduction in nutrient and pesticide losses by 50% respectively, 100% of urban water subjected to tertiary treatment and reduction in micro-pollutants and emerging contaminants (e.g. pesticides, pharmaceuticals, biocides, PFAS) by 50%. Financial support to reducing nutrient and pesticides losses from agriculture will be delivered solely via CAP since Mission Starfish does not have a budget allocated to securing these targets. However, in terms of other reasons for water quality failures, the Mission does envisage a significant investment in hydromorphological restoration through de-damming as well as major investments in advanced waste water treatment to reduce point sources to zero. Other important aspects of Mission Starfish include stimulating societal interest in protecting water ecosystems, e.g. through citizen science projects, revamping and integrating water-related governance and objectives through Integrated Ocean and Water Plan for Europe (2022-2030), and improving data availability and accessibility through EU digital platforms.

Table 1 A list of agricultural practices (eco-schemes) proposed in the new CAP in Pillar 1 with an aim to protect or improve water quality and reduce pressure on water resources, adapted from (European Commission, 2021)

Type of practices	**Eco-scheme**
Organic farming	Conversion to organic farming (b, c, d, f, g)
	Maintenance of organic farming (b, c, d, f, g)
Integrated Pest Management	Buffer strips (c, e, f)
	Mechanical weed control (c, e, f)
	Fallow laying with species composition for biodiversity (c, e, f)
Agro-ecology	Crop rotations, mixed crops & cover crops (a, c, d, e, f)
	Soil cover & catch crops above conditionality (a, b, c, d)
	Low intensity grass-based livestock system (a, c, d, g)
	Climate change resilient crops/plant varieties (b, c, e, f)
	Mixed species/diverse sward of permanent grassland for biodiversity purpose (c, d, e, f)
	Practices/standards as under organic farming rules (b, c, d, f)
	Establishment and maintenance of landscape features above conditionality (a, c, d, e)
Agro-forestry	Semi-natural habitat creation and enhancement (a, c, d, e)
High nature value farming	Land lying fallow with species composition for biodiversity purpose (pollination, birds, game feedstocks, etc.) (c, e, f)
	Semi-natural habitat creation & enhancement (a, b, c, d, e, f, g)

	Fertiliser use reduction & low intensity management in arable crops (a, b, c, d, e, f, g)
Carbon farming	Rewetting wetlands/peatlands (a, c, d, e)
	Minimum water table level during winter (a, c, d)
	Appropriate management of residues (a, c, d)
	Establishment & maintenance of permanent grassland (a, c, d, e, f)
	Extensive use of permanent grassland (a, c, d)
Precision farming	Nutrients management plan, use of innovative approaches to minimise nutrient release, optimal pH for nutrient uptake, circular agriculture (a, c, d, f)
Improve nutrient management	Implementation of nitrates-related measures (c, d, e,)
	Measures to reduce and prevent water, air and soil pollution from excess nutrients such as soil sampling if not already obligatory, creation of nutrient traps (c, d, e,)

a. Climate change mitigation, including reduction of GHG emissions from agricultural practices, as well as maintenance of existing carbon stores and enhancement of carbon sequestration
b. Climate change adaptation, including actions to improve resilience of food production systems, and animal and plant diversity for stronger resistance to diseases and climate change
c**. Protection or improvement of water quality and reduction of pressure on water resources**
d. Prevention of soil degradation, soil restoration, improvement of soil fertility and of nutrient management
e. Protection of biodiversity, conservation or restoration of habitats or species, including maintenance and creation of landscape features or non-productive areas
f. Actions for a sustainable and reduced use of pesticides, particularly pesticides that present a risk for human health or environment
g. Actions to enhance animal welfare or address antimicrobial resistance

5. Will the new EU strategies bring in a step-change in improving EU freshwater quality?

The level of ambition in setting the goals for improving freshwater quality and adopting a holistic approach to solving complex and interlinked environmental problems by the new EU strategies and Missions is highly positive and much needed. The F2F, CAP and Mission Starfish targets focus on reducing pollution sources and their mobilisation from agricultural land through agro-ecological land and nutrient management practices, thus providing a source-focussed approach in contrast to the largely impact-based focus of the available WFD instruments (Boezeman et al., 2020) (Figure 1). This complementary approach to improving EU freshwater quality is critically needed, a step towards circular economy, and in line with the scientific evidence on complex impacts of pollution on freshwaters. However, we question the justification for and likely achievability of the freshwater related goals, mainly: ***to reduce nutrient losses by at least 50% while ensuring no deterioration in soil fertility; this will reduce use of fertilisers by at least 20% by 2030*** (European Commission, 2020b; European Commission, 2021) for the achievement of the WFD targets.

Firstly, it is intended that the required reductions in nutrient losses will be achieved through reductions in primary nutrient sources and their mobilisation by improving nutrient usage efficiency, eliminating surpluses and adopting eco-schemes (Table 1) and agri-environment-climate measures (AECMs). However, many of the proposed practices have already been available to farmers, e.g. via AECMs in previous CAP implementations and the Nitrates Directive (e.g. fertilisation limits and closed periods, manure storage) since 1991. Yet, major improvements in freshwater quality are lagging behind targets (European Commission, 2018; European Environment Agency, 2018), partly due to time lags between implementation of the measures and their impact (Meals et al., 2010) and challenges with adopting appropriate monitoring schemes to evaluate effectiveness of such practices (Jones et al., 2017). This makes the ambitious goal of reducing nutrient losses by 50% by 2030 seem unachievable (Garske et al., 2020), unless there is a very significant but so far unlikely shift in the design of the new CAP (Pe'er et al., 2019; Pe’er and Lakner, 2020; Scown et al., 2020).

A further new addition of the eco-schemes in the reformed CAP is envisaged to tip the balance in favour of further nutrient reductions, on top of what can be achieved by existing policy and adoption of the AECMs. However, the proposed agricultural practices in the form of eco-schemes show a large variation in their effectiveness. From the proposed eco-schemes, only reduction in fertiliser use, precision farming, and improved nutrient management are likely to lead to significant improvements in freshwater quality (Liu et al., 2017; Macintosh et al., 2018). A high level of flexibility in selecting eco-schemes offered at national level is also a likely potential threat to reaching both national and EU nutrient and pesticide reductions goals (Garske et al., 2020). Each Member State can offer one or more voluntary eco-schemes with farmers having the freedom to participate (European Commission, 2019c). The new CAP also puts a greater emphasis on eco-schemes rather than AECMs which is reflected in up to 20% reductions in Pillar 2 financing compared to 2014-2020, with only small reductions of ~1% in Pillar 1 funding (Matthews, 2019). These financial cuts in the EU contribution to the new CAP put a larger burden on Member States in co-financing Pillar 2, which might result in a different level of commitment between the EU countries to reaching environmental goals and freshwater protection. The European Commission will need to approve national Strategic Plans to address CAP objectives, but considering the flexibility and financial cuts, the approval process might further delay implementation of measures to reach 2030 nutrient and pesticide goals.

Secondly, it is not fully clear how the progress in reducing nutrient losses will actually be monitored or even measured, nor how the acquisition of such crucial data will be paid for. Furthermore, the same targets for phosphorus and nitrogen suggest that reductions in their losses are equivalent from the environmental point of view, despite significant differences in ecological impact of each nutrient (Davis et al., 2018). Since the focus is on reducing the primary sources, farm-scale seems as an appropriate level to verify this progress. However, significant reductions in field or farm-scale nutrient losses do not necessarily translate into ecologically significant reductions at the catchment scale. For example, in a small agricultural catchment (7.4 km^2) where all arable fields were subjected to treatment with lime to reduce phosphorus losses, observed reductions in phosphorus losses reached up to 80% for individual fields but only 15% at the catchment-scale (Bieroza et al., 2019). A growing body of literature shows that solely reducing the primary pollution sources might not be sufficient to achieve environmental targets at the catchment-scale and simultaneous reductions in the secondary and legacy sources are needed (Hoffmann et al., 2020). An active drawdown of soil phosphorus levels to or just below the agronomic optimum (i.e. addressing secondary sources of pollution) can be effective in reducing legacy sources and improving water quality (Withers et al., 2019), while maintaining agricultural yields (Liu et al., 2019). Thus, significant nutrient loss reductions in agricultural landscapes cannot be achieved without deterioration in soil fertility, which is a goal of the F2F and Mission Starfish. Bridging this apparent contradiction will require a detailed understanding of the effectiveness of the agro-ecology, precision farming and nutrient management practices proposed in the new CAP eco-schemes in maintaining soil fertility while delivering multiple agronomic and environmental benefits.

Secondary sources can be reduced by restoring agricultural ditches, streams and wetlands and their riparian zones in agricultural landscapes (Hoffmann et al., 2020). These small ditches, streams and wetlands effectively transport, store and remove nutrients, sediments and pesticides (Figure 1), and are, therefore, important in controlling downstream water quality and biodiversity (Abbott et al., 2018; Bieroza et al., 2018; Creed et al., 2015; Wollheim et al., 2018). Mission Starfish emphasises the importance of re-naturalisation of freshwaters, including specific targets for removing river dams from 30% of European rivers and addressing hydromorphological pressures in 30% of European water bodies (European Commission, 2020d). However, due to their hydro-chemical and ecological significance, active restoration of agricultural ditches and streams in the agricultural headwaters must also be an integral part of the new policy in order to address both main reasons for WFD failures – hydro-morphology and diffuse pollution from agriculture (EEA 2018). This is also supported by the recently adopted Biodiversity 2030 Strategy (European Commission, 2020a) which states that '*the EU's legal framework on water is ambitious but implementation is lagging behind and enforcement must be stepped up. Greater efforts are needed to restore freshwater ecosystems and the natural functions of rivers in order to achieve the objectives of the Water Framework Directive*'. Most of the planned investments seem to target large river basins and their floodplain restoration and reinstating of ecological flows in 25000 km of EU rivers.

The Green Deal like initiatives have been proposed in several countries, e.g. USA, UK, Indonesia, South Korea, Australia and Canada, but few are actually in place (European Commission, 2019a). The EU Green Deal is only a few years young and still in its early stages of its long term (30 year) goals (Politico, 2020). Its continued reliance on CAP, in which larger farmers obtain the largest grants, even after its proposed reform, will make it less flexible than countries like UK to reward farmers for looking after their land in a way that is good for society ('public money for public goods') (Harrabin, 2020). Furthermore, compared to the proposed US 'Green New Deal' and Indonesia's 'Low Carbon Development Initiative', it has a less ambitious proposed decarbonisation timeline (Moran, 2021). The EU aims for carbon neutrality in 2050, more comparable to South Korea's goal (European Commission, 2019a), but is more ambitions than Japan's luke warm 'innovative transition towards a zero-carbon and resilient society' (Matsushita, 2020). Other initiatives include the Australian Green New Deal ('Quit Coal and Renew Australia') (Parliament of Australia, 2020), India's co-fund of five Green Deal topics in their efforts towards building a low-carbon climate solution (European Commission, 2020c) and China's green ambitions which are likely to be pitched towards a higher decarbonisation drive and indigenous tech innovation (Holzmann, 2021). Whatever, ambitions are stated in the individual Green Deals, ultimately cooperative (global) solutions are needed to achieve a greener low carbon planet. However, compared to the EU Green deal, to our knowledge these other strategies are primarily focussed on GHG mitigation and do not provide a holistic sustainable development framework delivering UN Sustainable Development Goals that would include freshwater impacts. Thus, the EU Green deal aims to provide 'a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use' (European Commission, 2019a).

6. Do new strategies achieve a systemic approach and policy integration?

The new strategies linked to EU Green Deal are generally consistent with each other, but links with existing policies related to freshwaters, mainly those with the WFD and Nitrates Directive carry large implementation risks. This can potentially introduce further compartmentalisation of water-related regulation instead of the integration mentioned e.g. in Mission Starfish (European Commission, 2020d). Eutrophication is acknowledged as a very significant reason for environmental degradation and significant investment is envisaged for hydromorphological restoration and to address pollution from waste water (Mission Starfish). However, the proposed instruments for addressing diffuse pollution from agriculture – the second most important reason for the failure to achieve Good Ecological Status under the WFD, rely on the reform of the CAP. Unfortunately, the analysis of the CAP reform proposals to date suggests that this is unlikely to bring about the much-needed significant environmental improvements (Pe'er et al., 2019; Pe'er and Lakner, 2020; Scown et al., 2020). The emphasis on a systemic approach in Green Deal and Mission Starfish is much needed to address the complexity in the pollution continuum (Figure 1), however we feel it is not consistently followed through. For example, Mission Starfish relatively downplays the importance of freshwaters vs. oceans, which could be partly because of already existing regulation for freshwaters, e.g. in the form of the WFD, Nitrates and Pesticides Directives. Another complication is that some instruments are still in preparation, e.g. the Zero Pollution Action Plan for Air, Water and Soil will be adopted in 2021 (European Commission, 2019a) and the new CAP will become operational no earlier than 2023. Since these are key tools in reaching the freshwater targets, this delay makes the 2030 implementation for 50% reduction in nutrient and pesticides losses more elusive.

7. Towards integration of EU water-related strategies and realising freshwater quality goals

To achieve significant improvements in freshwater quality, it is necessary to target the entire pollution continuum, and not only its end points, i.e. sources/mobilisation by Green Deal, F2F, CAP and delivery/impact by WFD. New strategies, policy instruments and integration with existing policies need to focus not only on the primary, but should also deal with secondary and legacy pollution sources, as these are key to controlling pollutant losses and long-term effectiveness of mitigation measures. Strategic plans to reduce these 'forgotten' pollution sources in agricultural landscapes should be prepared and followed through with a selection of eco-schemes and AECMs in the new CAP focusing on depleting these sources. Mitigation of secondary and legacy sources is, however, more challenging compared to land-based practices and thus relatively less effective in the short-term (Hoffmann et al., 2020; Macintosh et al., 2018). This relatively lower effectiveness accompanied by measurement uncertainty, but coupled with benefits of preserving biodiversity and reducing climate impact, should be effectively communicated to farmers and stakeholders to inform their decision on choice of mitigation options. Mitigation of the legacy sources requires, on the other hand, drawdown of soil phosphorus levels to or just below the agronomic optimum, which is at odds with the F2F goal of maintaining current levels of soil fertility. These potential trade-offs in agricultural productivity vs. environmental protections need to be carefully evaluated, following recent scientific findings (Withers et al., 2019).

To fully embrace the Green Deal with its holistic ambition, a special emphasis is needed on the pollution delivery to and within the stream network. Current EU policy treats freshwaters simply as conveyors for water and pollution from its land sources to impacts observed in seas and oceans. However, as the scientific evidence shows, ditches, streams and rivers draining agricultural landscapes are critical in reducing pollution loads (Heathwaite and Bieroza, 2020). We argue that a more active approach in restoring freshwaters in headwater agricultural catchments is the possible missing piece needed to fulfill the Green Deal objectives and specific freshwater targets. Remediation and restoration of agricultural ditches and streams to build up ecosystem services (protection against flood and drought, eutrophication and sediment regulation, water purification, biodiversity and habitat provision) therefore should become an integral element in the future CAP. This will complement existing efforts in restoring large-scale floodplains and rivers in Mission Starfish and contribute towards the need for holistic ecosystem restoration of freshwaters (van Rees et al., 2020) and their upstream contributing areas.

Despite their holistic and systemic ambition, the new strategies do not address the full complexity of the pollution continuum and controls on freshwater quality. Potential effects of envisaged nutrient load and pesticide application reductions on freshwater quality and ecological health need to be quantified, and the choice of the 50% reduction threshold by 2030 deadline needs to be justified. The 2030 deadline for nutrient and pesticide reductions in the Green Deal and F2F need to be linked to the goals and timelines of the WFD, while the time-lags in translating source reduction into desired freshwater improvements should be considered. With the adoption of the Green Deal and its high level of ambition, we argue that this is a lost opportunity in integrating, strengthening and setting water-related policies into scientific-evidence context. There are several aspects of pollution continuum complexity that should be considered by the new strategies. For example, the varying degree of effectiveness of different eco-schemes and AECMs in reducing pollution and improved monitoring of the effects of these management actions (Waylen et al., 2019). Novel monitoring strategies are required to evaluate the short-term and long-term effect of these interventions, with a focus on a range of ecosystem services, smart indicators of biotic and abiotic function, and using novel monitoring techniques e.g. *in situ* optical water quality sensors and analysers and monitoring approaches e.g. citizen science.

Trade-offs between reducing different pollutants require explicit consideration since phosphorus and nitrate, and different pesticides behave differently in soils and water and therefore have different mitigation requirements. Some eco-schemes and AECMs can be beneficial for one type of pollutant but detrimental for others, e.g. cover crops effectively reduce nitrate and particulate phosphorus but can increase leaching of dissolved phosphorus, leading to undesired pollution swapping effects (Stevens and Quinton, 2009). To account for potential trade-offs between mitigating soluble and particulate forms of nutrients and pesticides, farmers need to be able to make an informed choice in their selection of practices or schemes. Therefore, a Catchment Sustainability Tool for Nutrients should be developed alongside the proposed Farm Sustainability Tool for Nutrients to inform sustainable transition in agriculture and provide a catchment-scale analysis of multiple stressors, their interactions and potential trade-offs in mitigation. Implementing eco-schemes and AECMs without a catchment-scale integration might not bring about the desired improvements in freshwater quality and may lead to detrimental effects when one pollutant is reduced at the expense of increase in another (Bieroza et al., 2019).

Catchment and basin scale are where the old and new water-related strategies should meet to bring the desired improvements in freshwater quality (Figure 1), e.g. through integration of farm- and catchment-scale pollutant analysis tools. This is critical due to the already complex make-up of pollution sources, transfers and impacts in the catchments but also emerging and worsening threats to freshwater quality, like climate change and emerging contaminants (Bol et al., 2018). With this high level of uncertainty in freshwater systems, there is a need to evaluate combined effects of different pressures and stressors on freshwater quality and their potentially different role under future climate. There are many unknowns in the freshwater pollution continuum, including some ecological surprises in response to changing pressures and multiple stressors. While a very welcome step, the proposed reductions in nutrient and pesticide losses may not be enough to ensure good ecological status of EU water bodies by 2027 or even 2030, since physical pressures driven by climate change (e.g. temperature increase, flow discontinuity, higher occurrence of hydrological extremes: drought and storm events) and eutrophication (oxygen and light depletion) may increasingly dominate freshwater quality issues in the future (Charlton et al., 2018; Woodward et al., 2016). For example, in many areas of Europe current catchment P loss mitigation efforts will not be sufficient to combat the effect of increased winter runoff due to climate change on P losses (Ockenden et al., 2017). Ultimately, we want to avoid a situation whereby the Green Deal's ambition to reduce nutrient and pesticide losses simply becomes a holy grail, impossible to implement in the dynamically changing interplay between different freshwater quality controls. We therefore advocate explicit integration between the much needed source-control-focused approach of the Green Deal and the predominantly impact-focused approach of the WFD instruments, without which major improvements in European freshwater quality simply will not be possible. As the current proposals leave much of the diffuse pollution continuum to the new but untested reformed CAP, there is a great and tangible risk that the Green Deal strategy may come to represent another missed opportunity to improving EU freshwater quality.

8. Conclusions

The Green Deal supports the ambition of EU27 to be a world leader and game changer in environmental policy for the welfare of people within its territories. However, whilst highly aspirational, the stated goals should also be measurable and aligned with the understanding of environmental complexity. To maximise the Green Deal's opportunities for tackling diffuse pollution from agriculture and achieving the delayed freshwater quality targets, we suggest the following:

- It is absolutely imperative to ensure that the CAP reform, as a major path for the delivery of the Green Deal and F2F ambitions, adopts effective instruments for tackling of the agricultural pollution sources along the pollution continuum 'from source to impact'.
- These should be accompanied by rigorous, standardised and appropriately funded monitoring of the effectiveness of the proposed eco-schemes and agri-environment-climate measures to allow adaptive management and ensure that environmental objectives are being fully achieved.
- To avoid potential problems with pollution trade-offs at catchment and basin scales, farm-scale and catchment-scale analysis of pollution risks to freshwater quality need to be integrated and used to inform stakeholders' decisions on the choice of appropriate eco-schemes and agri-environment-climate measures.
- The hydromorphological restoration schemes should also be available to restore headwater agricultural streams and ditches and their downstream floodplains in order to reduce secondary pollution sources in agricultural landscapes.

- The agro-ecology schemes should evaluate the feasibility of nutrient reductions below the agronomic optimum to improve water quality in catchments subjected to pollution from legacy sources.
- Hydromorphological and diffuse pollution pressures are likely to be exacerbated under future climate. Therefore, proposed eco-schemes and agri-environment-climate measures should also include measures to reduce negative impacts of increased temperature and hydrological flashiness on freshwaters through active restoration.

The Green Deal offers an ambitious framework for achieving the SDGs and freshwater quality goals in a highly complex natural and policy landscape. However, its success will rely heavily on the appropriateness of the implementation instruments in F2F and CAP. We advocate the integration of the pollution continuum framework in the instruments for tackling agricultural pollution to ensure that the European water-related policy goals are truly and comprehensively addressed.

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