Towards the Baltic Sea Socio-Economic Action Plan

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Towards a Baltic Sea Socio-Economic Action Plan

Abstract

This paper analyzes the main weaknesses and key avenues for improvement of nutrient policies in the Baltic Sea region. HELCOM's Baltic Sea Action Plan (BSAP), accepted by the Baltic Sea countries in 2007, was based on an innovative ecological modeling of the Baltic Sea environment and addressed the impact of the combination of riverine loading and transfer of nutrients on the ecological status of the sea and its sub-regions. We argue, however, that the assigned country-specific targets of nutrient loading do not reach the same level of sophistication, because they are not based on careful economic and policy analysis. We show an increasing gap that exists between the state-of-the-art policy alternatives and the existing command-and-control-based approaches to the protection of the Baltic Sea environment and outline the most important steps for a Baltic Sea *Socio-Economic* Action Plan are outlined. It is time to raise the socio-economic design of nutrient policies to the same level of sophistication as the ecological foundations of the BSAP.

Key words: cost-effectiveness, incentives, manure, performance-based policy, innovation

1. Introduction

The greatest environmental challenge in the Baltic Sea is eutrophication and the ecological risks it causes (Reusch et al. 2018). The Baltic Sea Action Plan (BSAP), accepted by HELCOM member countries in 2007 and revised in 2013, aims to achieve a good ecological status of the sea. It defines overall reduction targets of nutrients (15 200 t P and 118 000 t N) as well as specific targets for all sub regions of the sea to be achieved by 2021 (HELCOM, 2013). BSAP is based on innovative ecological modeling of the Baltic Sea, combining riverine loading and transfer of nutrients with ecological description of eutrophication in the sea and its sub-regions (Backer et al. 2009). Thus, the BSAP has a firm rooting in the knowledge of the dynamics of eutrophication in the Baltic Sea. However, the ecological goals of the BSAP are mechanically translated to nationally assigned reduction targets, without consideration for whether such an allocation is cost-effective or economically justified in other ways, such as the equity of cost-burden sharing.

Since the acceptance of the BSAP, nutrient loading to the Baltic Sea has slowly decreased – by approximately 19 % for P and 24 % for N between the reference period of 1997-2003 and 2012-2014 (HELCOM 2017). The area of anoxic bottoms has been increasing, however (Carstensen et al. 2014). The slow progress in the implementation of the BSAP has some obvious reasons. In contrast to the science-based ecological modelling, the assigned country-specific reductions of nutrient loading have not reached the same level of sophistication. They have not been founded on a valid economic and policy analysis. Instead of being cost-efficient, they are unnecessarily expensive and considered unfair, especially as regards to country-specific allocation of cost-burden (Ollikainen and Honkatukia 2001, Gren 2008, Elofsson 2010, Hasler et al 2014, Nainggolan et al 2018, Reusch et al., 2018). The results of these studies suggest that there would be considerable cost savings if more of the nutrient emission reductions took place in Poland and Russia. On the other hand, Finland and Sweden would receive most benefits from improved water quality (Ahtiainen et al, 2013). As a result, achieving a cost-effective solution requires over-national thinking and hence faces various policy challenges.

Perhaps the biggest hindrance in designing efficient paths for achieving the abatement targets at the time when BSAP was signed, was a vague understanding of polluters' incentives, and difficulties in designing a policy that would take polluters heterogeneity into account. Since then, there has been a considerable progress in research on policy instruments, incentives and mechanisms, particularly in the context of water quality management (see Winsten and Hunter 2011, Xepapadeas 2011, Shortle 2017, Shortle and Horan 2017 for surveys). Despite this progress in knowledge, countries have rarely adopted innovative policies, such as using environmental benefit indexes, tendering systems or trading and compensation mechanisms. Furthermore, means to promote citizens' engagement and awareness are practically lacking. Today, an increasing gap exists between the new possibilities, and the existing command-and-control-based approaches to the protection of the Baltic Sea. It is time to raise the socio-economic design of nutrient policies to the same level of scientific excellence as the natural science underpinnings of the BSAP.

The objective of this paper is to outline, at a strategic level, the most important steps to improve nutrient policies in the Baltic Sea region. We identify the biggest weaknesses of current policies and suggest economic instruments that are better suited for regulating point and nonpoint sources of nutrient loadings. We emphasize the need for technological developments in nonpoint source to reduce loading, and analyze key factors needed to promote it. We demonstrate the need for coherence between water and emerging climate policies, especially in the case of agriculture. We point out the main obstacles to the improving of policies. We outline basic ingredients for an effective Baltic Sea Socioeconomic Action Plan. Such a plan is needed not only for national policy makers, but also for the European Union's policies relevant for combating eutrophication, such as Common Agricultural Policy (CAP), environmental directives and the Baltic Sea Region Strategy.

The remainder of the paper is organized as follows. Section 2 compares point and nonpoint sources in terms of nutrient reduction possibilities and costs. Section 3 emphasizes the need for coherence in water and climate policies. Sections 4 and 5 extend the analysis to the topics of technological development and voluntary compensation schemes. Finally, the paper summarizes the implications of our analysis for a future, science-based socioeconomic action plan.

2. Reduction potential versus abatement costs – point and nonpoint sources

There is a fundamental difference between nutrient load policies aimed at point sources, such as waste water treatment plants (WWTPs) and industry, and those targeting nonpoint sources, such as agriculture and forestry. Point sources release nutrient loads via definite points, pipes, so that their loads can be measured and directly subjected to regulation. Nonpoint loads, in contrast, are diffuse, coming from surface and drainage, they are stochastic due to varying weather and often associated with a delay between action and releasing loadings. Therefore, it is not possible to register the exact amounts of nutrients that are released from a given field parcel or forest plot making it impossible to levy policy instruments directly on loads (Shortle and Dunn 1986). The only possibility is to levy instruments on inputs and management practices that indirectly determine nutrient loads. Thus, for nonpoint sources only a second-best policy in an option. Furthermore, while effective technologies can be employed to reduce loads from point sources, often at low costs, measures in agricultural nonpoint are less effective and sometimes more expensive and uncertain due to stochasticity and spatial heterogeneity in governing biogeochemical processes. Therefore, cost effectiveness analyses give much higher abatement rates in point sources than nonpoint sources. This feature is sometimes understood poorly, for instance, BSAP gives little attention to the possibilities and need of reducing nitrogen in WWTPs cost-effectively.

Table 1 provides information on nutrient inputs to the Baltic Sea apportioned to sources including natural background and atmospheric deposition on the sea. The table is based on annual reporting by the contracting parties to HELCOM (Personal communication Lars Svendsen, DCE, Aarhus University). Diffuse sources, mostly agricultural, are responsible for 39 % of nitrogen and 49 % of phosphorus loads, while the respective shares of point sources are 8 % (N) and 16 % (P).

Table 1. Nutrient loads (tonnes) to the Baltic Sea in 2000 and 2014 (Personal communication Lars Svendsen, DCE, Aarhus University). Figures are actual, non-climate normalized loads. Point sources include point sources directly to the sea and point sources to inland surface waters.

	N	P	N	P	Reduction by 2014	
Source	2000	2000	2014	2014	N	P
Natural background	188000	9200	165000	8000	23000	1200
Point sources	72000	8400	58000	4400	14000	4000
Diffuse sources	434000	20300	293000	13800	141000	6500
Atmospheric deposition on BAS	310000	2100	240000	2100	70000	0
Total	1004000	40000	756000	28300	248000	11700

To illustrate the importance of the effectiveness of measures and their costs, consider cost estimates of nutrient reduction for example in the Finnish agriculture: reducing 20% of nitrogen and phosphorus entails marginal costs € 9,4 (kg N)$^{-1}$ and € 223 (kg P)$^{-1}$ (Hyytiäinen and Ollikainen 2012). Compare these estimates to marginal abatement costs in waste water treatment plants (WWTPs) for the Baltic Sea: 90% reduction of nitrogen costs roughly € 11 (kg N)$^{-1}$ and 95% reduction of phosphorus costs € 17 (kg P)$^{-1}$ (Hautakangas et al. 2014). The difference in marginal costs between the two sectors is huge especially when it comes to cost of phosphorus reduction. Adapting from Hautakangas et al. (2014), if WWTPs abate according to Urban Waster Water Directive (UWWTPD), their annual abatement costs are less than 500 million EUR. Increasing the abatement rate up to 95% P and 90% N in WWTP in the Baltic Sea Region would increase the costs roughly to 1100 M€ and produce a reduction of N 85 000 t and P 9 600 (Hautakangas and Ollikainen 2018) giving as the cost increase 600 M€. this reduction in WWTP.s and allocating the remaining part of the reduction target to agriculture would keep the total costs low. Ahlvik et al. (2014) suggest that in the cost-effective solution the total cost on achieving the BSAP targets would cost about € 2 billion. Hasler et al (2014) estimate a total cost to 4.1 billion EUR for a similar solution. This range reveals some uncertainty on the costs and data. Nevertheless, following cost-effectiveness could lead to significant savings, relative to arbitrarily selecting targets for different measures.

This discussion provides a lesson: *cost-effective abatement with equalization of marginal abatement cost should be the guiding principle of nutrient policies towards point and nonpoint sources, because this principle reflects best the technological and economic possibilities to reduce loads the best.*

2.1. **Policies for point sources**

Abatement of nutrients in WWTPs and industrial point sources are the backbone of the Baltic Sea protection. Abating both nutrients in the WWTPs is certain and less costly relative to other sectors, albeit reducing nitrogen requires a high initial but a long-lasting investment. The best available technique facilitates higher emissions reductions than the abatement rates in the above example, as experience in many countries has demonstrated. Hautakangas and Ollikainen 2019 provide examples of abatement rates in various plants. They suggest that it would be justified to require WWTPs to abate at least 95% of phosphorus and close to 90% of nitrogen.

The main weakness of nutrient policies towards point sources is that both the EU's Urban Waste Water Directive and HELCOM recommendations are inattentive relative to current abatement possibilities and abatement costs, and we propose that they should be scaled up accordingly.

Another weakness of policies towards point source is their reliance on command and control instruments only. Countries should take further efforts to create better incentives to extend abatement beyond conventionally known abatement technologies. These efforts include economic incentives not only to increase abatement, but also to find new and innovative ways to treat waste water, such as extracting phosphorus from sewage water for new products and using the abatement process and sludge to produce energy.

A topic not so often discussed in the literature is abatement in industrial point sources. It is a drawback that HELCOM does not report data on industrial point sources' contributions to nitrogen and phosphorus loads at the Baltic Sea level. Database for improving water policies towards industrial point sources should be developed.

2.2 Policies for agricultural nonpoint sources

As the setting of optimal taxes or quantitative limits on runoff from fields is infeasible, many countries have agri-environmental schemes, which rely on farmers' voluntary participation and pay for taking conservation measures among the given a set of measures targeting nutrient loads. Designing an effective voluntary agri-environmental program faces three basic challenges: i) how to make it effective for water protection, ii) how to invite the farms that could contribute the most to the goals of the program (Schroeder et al 2015) , and iii) how to ensure that farms comply with the requirements (Winter and May 2001). Participation rates in programs depend on farmers' attitudes towards cleaner environment and the amount of the compensation relative to the costs and trouble of applying the measures (e.g., Pannell 2006). Higher compensation increases participation and more demanding and costly measures reduce it.

All member states in the EU have a voluntary agri-environmental program, which compensates the average costs of implementing the measures using area-based payments. Furthermore, the single farm payment (CAP Pillar I income support) contains cross-compliance conditions, which require farmers to undertake environmental measures to be eligible for the single farm payment. Figure 1 summarizes the participation of farmers in the agri-environmental schemes in 2013 (Source: Eurostat).

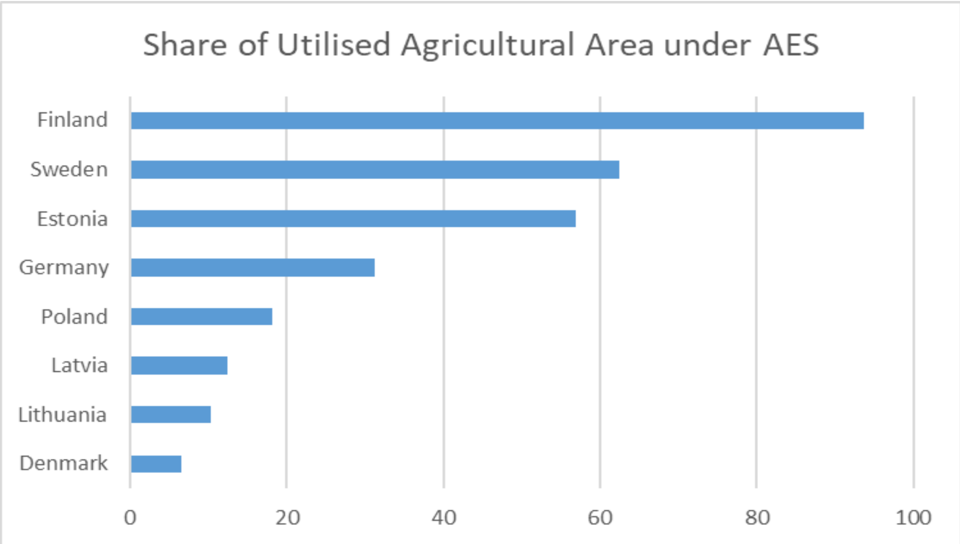

Figure 1. Participation rates in voluntary agri-environmental programs, AES in percent of utilized agricultural area.

Finland has the highest participation rate (over 90 %) and followed by Sweden (slightly over 60%), and Estonia (slightly under 60%). Denmark, Poland, Latvia and Lithuania have much lower participation rates. Caution should, however, be resorted when assessing the role of high participation rate in producing water quality improvement. There is a trade-off between participation and ambition. For instance, Lankoski and Ollikainen (2013) demonstrate that the Finnish agri-environmental programme has been very generous providing large overcompensation, keeping low profit farms and marginal lands in production, and actually increasing nutrient loading. Hasler et al (forthcoming) find large heterogeneity among farm types in farmers' reservation prices to enter into voluntary AES.

The impact of the measures included in agri-environmental schemes on nutrient loads depends on their environmental effectiveness and local conditions. Most programs offer a set of measures for farmers to choose, such as buffer strips and buffer zones, reduced fertilization, catch crops, conservation or restoration of wetlands, grassland management, set-aside and winter time vegetation (Zimmerman and Britz 2016). Unfortunately, some abatement or conservation practices may have adverse effects on other environmental targets. For instance, a measure effective in reducing particulate phosphorus tends to increase the loading of dissolved phosphorus (Dodd & Sharpley 2016), or management designed for water quality may increase air emissions (Aillery et al 2005; Smith et al 2017).

We conclude that *negative side effects and lack of effective measures with low social costs is one reason for slow progress of nutrient abatement in agriculture*.

Another reason for the slow progress in reducing nutrient loading is related to the way the programs are tailored. The AES programs compensate farmers for taking the requested measures irrespective of their impacts on nutrient loads or other environmental effects. As a result, a farmer adopting a measure, which leads to little improvement in water quality receives the same compensation as a farmer, who can efficiently reduce nutrient loads. This is a clear waste of resources: both public funds and farmers' efforts. A shift to performance-based schemes, drawing on modelled impacts of input choices on loads, would lead to environmental effectiveness, promote the best measures in each location and provide a higher return to public funds. There are two promising avenues to improve performance of policies: a shift from flat rate (cost-based) subsidies to incentive-based instruments, and increasing environmental targeting (result-based measures) by introducing environmental benefit indexes. Both avenues facilitate improved environmental targeting and the incentive-based instrument help to use of government budget money more efficiently.

Latacz-Lohman and van der Halmsvoort (1978) demonstrate the usefulness of tendering over flat rate policy. Figures 2a and 2b use tendering to establish our argument in favor of performance-based instruments in an intuitive way. Consider an area-based support payment for participation in the national agri-environmental scheme. The payment compensates for the costs of taking measures to reduce runoff (such as buffer strips, gypsum, catch crops or structural liming). Let the annual government budget be *G* and the area payment *s* per ha. Suppose for simplicity that each farmer supplies a field parcel of size one hectare (denoted by *i*) to the program and implements some of the listed water quality measures on this parcel. The costs of these measures, c_i, differ between farms. Figure 2a orders the submitted parcels from the cheapest to the most expensive one. The horizontal axis measures the number of parcels, and vertical the costs and the subsidy.

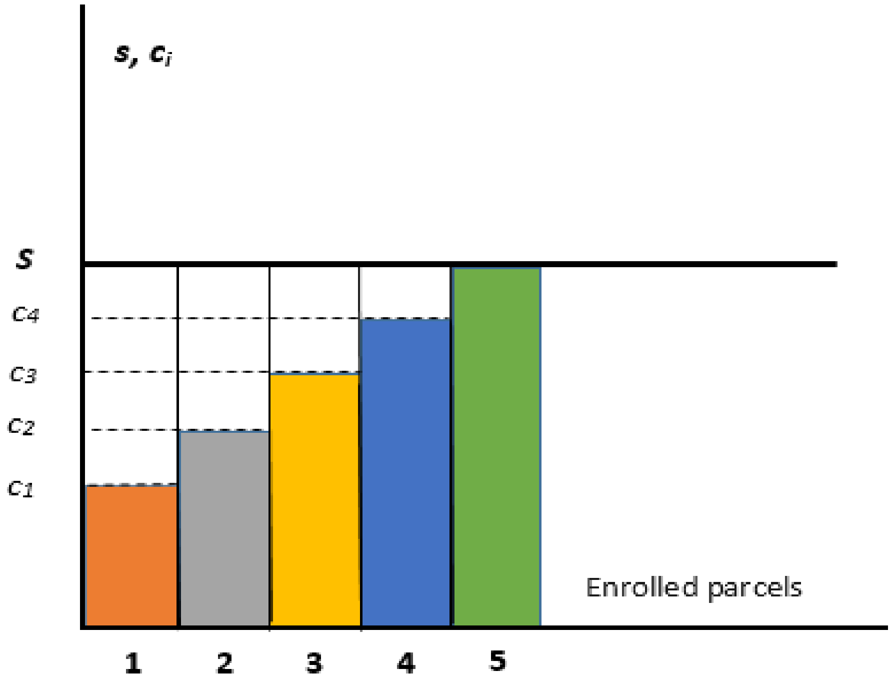

Figure 2a. Flat rate water policy and participation

In Figure 2a, parcel 5 is the last enrolled in the program, and s*5 = G (the budget is exhausted). The last parcel (5) receives a compensation that exactly matches its conservation costs but the others receive “overcompensation” (area between the pillars and the horizontal flat rate *s*), because their costs are lower that the payment. This overcompensation is information rent, as it results from the authorities’ incomplete information on conservation costs. Because of overcompensation only 5 parcels are enrolled in this example.

In environmental tendering the authorities announce the environmental goals (a reduction nutrient runoff) and invite farmers to offer their fields with assigned water protection measures to the program. While under a discriminatory tendering each enrolled field parcel receives exactly its bid, under a uniform tendering a uniform compensation is paid for all winning parcels (Romstad et al. 2012). Under tendering asymmetric information regarding the effects of implementing particular measures at different fields remains, but for cases with similar effectiveness of measures this leads to selecting the lowest cost options.

Figure 2b illustrates an outcome of a discriminatory tendering system under the original conservation costs. The sum of the cost pillar and new grey pillar indicates the size of the bid in each parcel. This sum indicates the bid curve of associated with supplied parcels. It locates above the true conservation cost curve but starts well below the flat rate *s* and cuts it at some point. Thus, the tendering system reduces information rents to farmers much below that of the flat rate subsidy. The information rent is the area above the bars and below the horizontal flat rate *s*. As the government saves money, more fields can be allocated in the program. In Figure 2b, two additional parcels are enrolled indicating that water protection effort has increased due to more efficient use of government budget money.

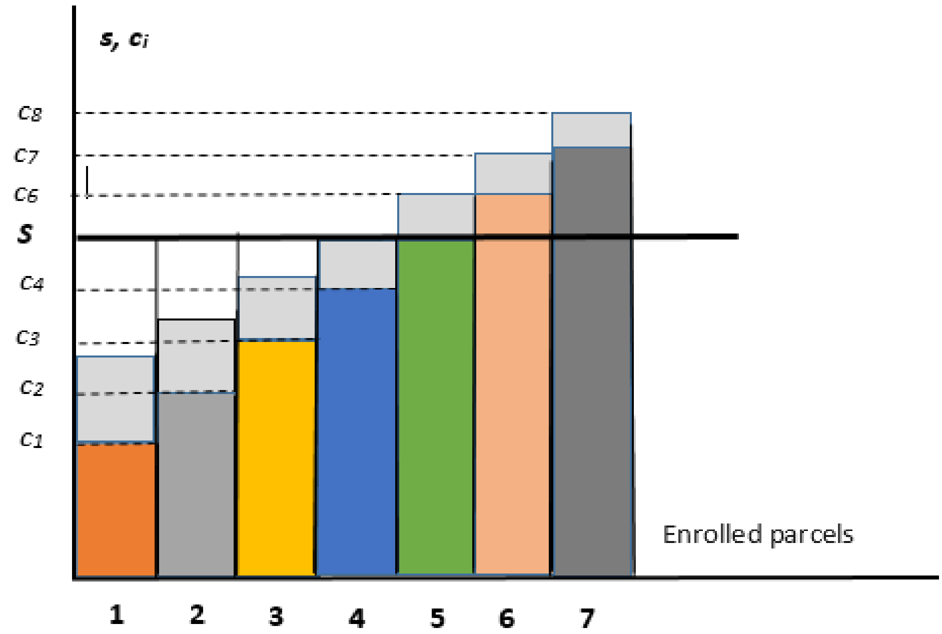

Figure 2b. Tendering system and participation

Both tendering and flat rate policies can be improved by using performance-based approach, such as environmental benefit indices (EBI), which assess the environmental performance of the chosen measures. An EBI is simply a number, scaled for instance between 0-1, 0-100. EBI is a product of chosen features drawing on their modelled impacts on water quality and weighted by their relative contribution to it. For instance, such features include slopes of fields, size of the buffer strips, or soil phosphorus reserves. How well the constructed EBI describes factors determining nutrient runoff, depends directly on the state of scientific knowledge. EBIs also help to differentiate fixed payment rates and targeting more efficiently environmental outcomes, as is done in the continuous CRP enrollment program (Hellerstein 2017).

In the Baltic Sea region, Finland arranged a tendering pilot with EBI focusing on a reduction of phosphorus loads. The EBI was constructed using three features: soil phosphorus content, slopes of fields and distance to water ways. Field parcels were enrolled in the program according to the ratio of EBI to bid. Information rents turned out to be very low, about 5-10% of the payments (see Iho et al. 2012). Despite a good experience, Finland has not adopted such a tendering system. One obstacle for introducing these performance-based incentives, that is, payments for the amount of reduced loads, are not feasible under the present EU regulation, which allows only compensation for the cost. This refusal to accept incentives, which are important for the performance-based instruments is artificial and mistaken: as Figure 2a shows, the area payment equals the conservation costs of only the last parcel and other parcels receive information rent. This rigid and unfounded regulation has prevented the introduction of modern instruments, like tendering systems to promote efficiency and targeting of environmental protection efforts.

Interestingly, there is an ongoing reform to change the CAP payment system to better facilitate country specific schemes, (European Commission 2019) and offer grants as incentives to farmers to adopt environmental and climate friendly practices, going beyond the costs incurred or the income foregone, but still conforming to least-trade-distorting rules (green box) set by WTO.

We emphasize the need to change the present rigid EU regulation to facilitate modern, incentive-based, and performance-oriented agri-environmental policy instruments in the process towards CAP post 2020.

2.3 Livestock production and manure: policies for semi-nonpoint polluters

Livestock production provides a challenge of its own. The increasing size of animal farms and high regional concentration of farms creates pressure on water quality - but may also provide possibilities for new innovative solutions (Aillery et al 2005; Schnitkey & Miranda 1993; Harrison et al. 1996). A livestock farm has barns and manure storages with possible leakages, and they are from a policy angle point sources. Cultivation of fodder, crop, and pasture are in turn sources of diffuse loads but manure complicates cultivation and land use in livestock farms.
Manure is kept in storages that may leak and sometimes with detrimental impacts. When manure is used as a fertilizer and spread on the soil surface it may easily release to water ways. Water protection can be promoted by renovating all manure storages, facilitating better timing and utilization of the manure applications, and shifting to more efficient spreading technologies. Jansson et al. (in the present volume) find large differences in the load reductions from manure investments between the countries. While the potential is modest in Denmark, which already has mandatory and high requirements to utilization of nitrogen in manure, the effects are higher in Sweden, Finland, Poland, and the three Baltic states. Sufficient storage capacity is important for farmers to be able to apply the manure on fields during the period when the crops grow and utilize the nutrients from the manure, which is spring and early summer (Tybirk et al, 2013). The capacity requirements differ between 5 and 10 months in countries around the Baltic Sea. Data are scarce documenting current capacities, but there are options for improvements to facilitate a better utilization. The type of slurry also affects the ability to utilize the nutrients. While the share of slurry is 80% in Denmark, this share is 5-10% in Poland. Overall, nearly 50% of the manure in the Baltic Sea region is solid (Tybirk et al, 2013).

Thus, we conclude that there is potential for increasing investment in manure storage to reduce manure leakage cost-effectively.

The development of livestock units and livestock farms has followed a similar pattern in all Baltic Sea countries. From 2005 to 2013 the number of bovine animals has remained approximately the same in all countries, with a slight decrease in total numbers (from 17,869 thousand livestock units (LSU) to 17,273 LSU). The number of pigs has decreased in all countries, with a total decline of 14%. The poultry production has increased in almost all countries with a total uptick of about 21%. The strongest trend, however, lies in the number of livestock farms: it has decreased by almost 40% indicating also increasing farm size and manure concentration (Eurostat 2018). The same structural development will continue, generating increasing pressure for local manure management.
The structural change in livestock farms has important implications on the availability of land for manure applications. Increased farms sizes entail higher risks that manure will be over-applied on the fields closest to animal facilities. Solutions to tackle the problem vary over countries. In many countries the Nitrate Directive or phosphorus fertilizer limits command that expanding livestock farms have enough manure spreading area. Clearing peat land forest to fields in Finland has been very detrimental, because new fields have increased deforestation, GHG emissions, and nutrient runoff. Denmark has promoted biogas production, which provides climate benefits but does not alleviate the transportation cost problem unless nutrient separation techniques are adopted.
Thus, current policies have not adapted to the rapid increase in the size of livestock farms (Kauppila et al. 2017) and only few innovations have taken place to solve the manure problem. One reason for this is that livestock farms in most places have not been subjected to tight regulation on manure issues (Jansson et al, submitted manuscript). Large livestock farms are, however, industrial plants and should be treated as such. Environmental permits provide a tool to promote progress in solving the manure problem. Experience from the US poultry industry provides a good example how things may evolve. Broiler operations in the Delmarva Peninsula, U.S produce more than 600 million birds in a year (Kleinman et al 2011). Regulation of poultry litter from large farms got more stringent as the states (Delaware, Maryland and Virginia) responded to water quality issues of the Chesapeake Bay. Delaware, for instance, implemented fully The Delaware Nutrient Management Act in 2007. The recent emergence of brokers and industrial size poultry litter processors, represents an innovative response of the industry to

tightened regulation (https://www.perduefarms.com/news/press-releases/perdue-expands-nutrient-recycling/ and https://www.voanews.com/a/mayland-chicken-manure-global-environmental-polution/3050598.html). Referring to this experience, we argue:

Tighter regulation of livestock production and the processing manure are important to obtain new technological solutions and business opportunities.

Manure contains nutrients in an uneven agronomic ratio: too much phosphorus relative to nitrogen. Farmers usually target nitrogen fertilization, and ignore the applied excess phosphorus, as it does not reduce yields. This creates spatial and temporal challenges for phosphorus policies. Thanks to increasing transport costs, farmers spread manure closer to the farm center and use mineral fertilizers in more distant fields (Schnitkey and Mirada 1993). Lötjönen et al. (2019) demonstrate that, the same pattern takes place also in the socially optimal solution but manure is spread less at each distance and for a longer distance than in the private solution. Therefore, the phosphorus content of soil is higher closer to the farm center. Large phosphorus reserves in the soil increase dissolved reactive phosphorus loads, which is directly available for algae growth creating the need of controlling soil P.
Figure 3 illustrates the pattern manure spreading with horizontal axis denoting distance from farm center. The optimal nitrogen fertilizer intensity in the upper panel decreases with distance and at the critical distance using a constant amount of mineral nitrogen becomes profitable. The lower panel indicates initial soil phosphorus status and the accumulation of phosphorus from manure in soil over time, reflecting the annual phosphorus fertilization by manure, the uptake of phosphorus by crops and soil chemical processes (Iho 2010). Soil phosphorus content decreases with distance, but assuming a constant use of mineral phosphorus, becomes constant. This implies that nutrient runoff differs between parcels in livestock farms.

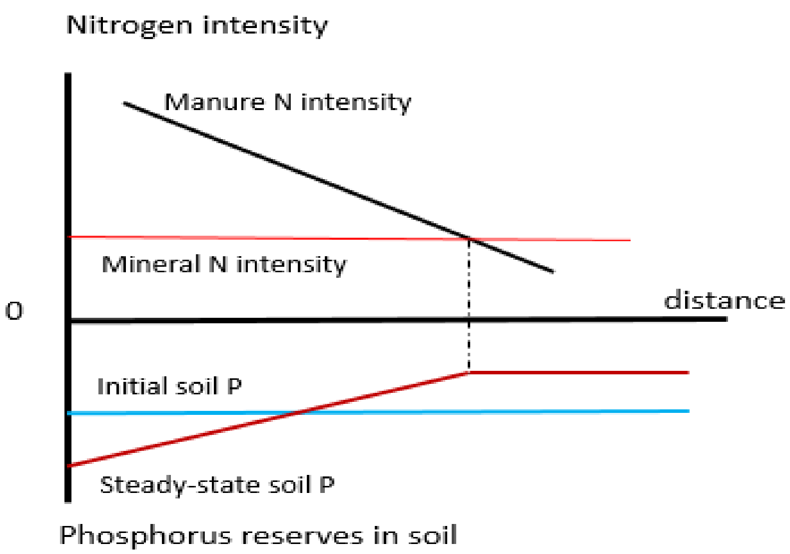

Figure 3. Private and socially optimal spatial pattern of manure spreading from farm center

Figure 3 exemplifies the spatial and temporal challenges of phosphorus policies in livestock farms. Unlike in crop production farms, differentiated P policy is optimal, albeit difficult to establish for livestock farms. Furthermore, reducing phosphorus loads will take time, because runoff of dissolved reactive phosphorus depends on soil P, which changes very slowly over time. A target value could be set on the steady state soil P to define the upper limit on phosphorus fertilization and thereby on manure spreading per hectare (Iho 2010). As the reduction is possible only in a long-run, short-term measures, such as gypsum or structural liming, are needed to reduce phosphorus leakage in the short run (Kosenius and Ollikainen 2019). Finally, a tax on mineral fertilizers impacts manure spreading making it more profitable to use manure on more distant

fields. Farmers reduce manure use on all locations to make it last for the new locations (Lötjönen et al. 2019).
Increasing farm sizes and regional concentration may provide a standpoint for new solutions to the environmental problems related to manure. With strong spatial concentration, it may become profitable to process the manure in industrial scale facilities providing a way out of the problems of large scale animal production. It would also help prevent spatial accumulation of manure nutrients by processing them into forms less expensive to transport; and over-application of the relatively more abundant manure nutrient by decoupling nitrogen and phosphorus fractions. Moreover, it would offer livestock farmers the possibility to focus on the core of their businesses instead of with low costs of meeting the manure regulations. After all, regulatory issues of manure management are found to be important factors when animal farms are making their relocation decisions (Stirm and St-Pierre 2003). Essentially, this would be a Turn Key solution for farm manure management under wise regulation.

Our suggestion is that promoting industrial scale treatment of manure in the food processing sector would provide a solution to the multiple environmental challenges created by current manure management in livestock farms.

3. Coherence of water- and climate-related policies

There are no effective climate policies towards agriculture at the moment but by 2020 the land use sector will become a part of EU's climate policy. And rightly, agriculture must make its share in climate mitigation and adaptation efforts. In the climate context, agriculture presents at the same time a problem and a solution. GHG emissions from cultivation, soil and animals are considerable and boost global warming, while nutrient runoff has regional impacts on water quality. Agriculture is a solution when reducing emissions and especially sequestering carbon in soils. Not all measures, however, promote both water quality and climate targets. It is important to ensure coherence between climate and water policies targeting agriculture.
Crop rotation with legumes is beneficial for both climate and water ecosystems (Lötjönen and Ollikainen 2018). Legumes help to reduce the use of mineral fertilizers by fixing nitrogen from the air and providing the residual fertilization effect for crops to be grown the following year. Legumes, buffer strips, and crop rotation promote simultaneously both climate and water goals. A constraining factor is limited demand for legumes implying that it is well-suited to livestock production areas only. Here, increasing ambition of the EU's legume policies would promote both water and climate targets.
Introducing climate policies to livestock production provides a challenge, as they have only few possibilities to reduce GHG emissions. For instance, both manure management and diet make only minor contributions. The main source of GHG emissions is methane emissions from animals and currently the only known means to reduce emission from animals is to reduce their number. Water policies in contrast target a larger set of choices and provide livestock farms a leeway to adjust cultivation and manure handling without reducing the number of animals. Thus, climate policy hits more strongly on the profits of livestock farms (Lötjönen et al. 2019). The water quality targets must not be compromised when climate policy is given more attention (Nainggolan et al 2018). Thus, we emphasize:
Introducing the much required climate policies to agriculture must be made in full coherence water quality targets requiring novel performance-based types instruments for agriculture.

4. Incentives for innovation

Agriculture in the Baltic Sea region needs higher productivity, active climate mitigation, and better performance in promoting water quality. Growing population in the catchment imply an increased pressure on surface water quality. Society must promote long term solutions for all these issues through improved technologies, production systems and social discoveries. The role of environmental policy for innovation and technological development is therefore important. Three questions regarding innovations are of particular interest: i) Do current policies provide sufficient incentives for innovation? ii) If not, how can the incentives be improved? iii) Will the novel technologies be adopted by the intended users?

Markets suffer from under-provisioning of innovations: innovators' net gains from innovation are small in comparison to the overall gains, because innovations could be copied by other firms (Goulder and Parry, 2008). Stringent environmental policies encourage innovation if they imply that polluting becomes more expensive, allow the polluter freely to choose among alternative abatement technologies, and credit the effects of the novel technologies against the firm's abatement obligations. The choice of policy instrument is crucial for providing incentives for innovation: market based instruments, such as taxes and tradeable permits tend to perform better than command and control (Requate, 2005). If command and control is applied, performance based policies provide stronger incentives for innovation than design standards, i.e., regulation of technology use (Shortle and Horan, 2017). Currently, taxes and tradable permits are absent from water quality policies in the Baltic Sea region. Instead, performance standards are widely used for wastewater treatment plants, while design standards and technology specific subsidies are common in the agricultural sector. Incentives for innovation in abatement technology are weak, especially in the agricultural sector where the environmental effect of novel technologies that are not subsidized does not increase farm profits.

A comparison of environmental policies towards WWTPs and agriculture provides a good example. Analyzing Swedish environmental policies over 50 years for improved water quality in sewage plants, Häggmark Svensson and Elofsson (2018) show that these policies have increased the number of patents for technologies that reduce nutrient emissions by 40 to 70% in the years immediately following the introduction of new policy. In a corresponding analysis of agriculture they find no effect of environmental policy on innovation of nutrient saving technologies, suggesting that policies have been unsuccessful in this regard.

A next challenge is to make farms adopt novel technologies that reduce nutrient emissions to the environment. A study by Konrad et al. (2019), covering Poland, Sweden, Finland, Denmark and Estonia for three nutrient technologies (manure spreading, manure storage, precision fertilizing), confirms the observation from earlier studies that large farms have a higher propensity to adopt new and costly technologies (Lynne 1995, Fuglie and Kascak 2001). This suggests that the ongoing structural development in agriculture may be environmentally beneficial through its effect on technology adoption.

In order to strengthen innovation as a tool for meeting the Baltic Sea nutrient reduction targets at low cost, an increased use of market and performance based policies is needed. A first step could be to apply performance based policies for larger farms, hence treating them as point sources rather than nonpoint sources, as they have a higher propensity to adopt novel technologies suggests this would enhance both innovation and adoption of novel technologies. The second step would be to develop schemes for nutrient trading, either among point sources (Hautakangas and Ollikainen, 2019) or between point and nonpoint sources (Shortle and Horan, 2017). The scale of trading would be of central importance for the size if incentives for innovation, as it determines the demand for novel technologies from the users.

Innovation policy must be directly linked to water policies in agriculture in the Baltic Sea region by tighter regulation and use of market-based instruments.

5. Voluntary instruments and flexible mechanisms

The analysis has this far focused on policies or policy instruments that create favorable circumstances for point sources or farmers. The implicit assumption underpinning our discussion has been that once the incentives are set right, the actors will fill their roles for the required effects in the Baltic Sea environment. Voluntary actions by actors may nicely complement the mandatory policies towards point and nonpoint sources.

An interesting form of water policies is to extend ideas of carbon neutrality to water protection issues: companies, cities or private actors could strive for nutrient neutrality by offsetting their loads that remain after abatement. For instance, phosphorus neutrality is a worthwhile goal, as it promotes the quality of coastal waters. A municipal waste water treatment plant (WWTP) and city, or an industrial point source could offset their loads by buying reduction from another agent that can reduce loads at lower social costs. Moreover, municipal WWTPs could be willing to promote water protection if an equivalent sum of their investment could play for higher reductions elsewhere in the drainage basin. Therefore, pursuing nutrient neutrality should be promoted by creating transparent and clear systems for nutrient compensations. To provide an example, four Finnish WWTPs locating at the coast of the Gulf of Finland compensated their P loads by investing in abatement in Vitebsk, Belorussia.

More importantly, nutrient compensations may have a much higher status in the future. Water protection within EU is unified by the Water Framework Directive (WFD). The recent Weser ruling of the European Court of Justice (C-461/13) strengthened the legal status of WFD-specific water quality standards, which will be reflected in environmental permitting processes also around the Baltic Sea. Under a strict interpretation, an environmental permit cannot be given to an economic activity if it increases the pollution of elements critical to water quality standards.

To prevent the emergence of unintended constraints from well-intending regulatory changes, some flexibility should be built into environmental instruments. One option is utilizing nutrient offsets in the permitting process. In our example, the facility would create nutrient credits by decreasing the nutrient loading risk from the livestock facilities it collects the manure from. These credits would be taken into account when determining the net effect of the new facility on nutrient pollution. Similar practices could be used for many economic activities as long as the basic condition is met: the new or expanding economic activity, together with the offsetting credit generates a net decrease to total nutrient loading to the respective water body.

We must ensure that the regulation is keeping pace with not only the structural change and the challenges it imposes but also with new innovations that help mitigating nutrient loading.

6. Recommendations

Our analysis has identified weaknesses and possibilities for improvements in the Baltic Sea protection policies. For point sources the key weaknesses include too lax regulatory policies towards WWTPs and missing incentives for developing new and novel abatement solutions, for instance, to promote circular economy. For nonpoint sources, current CAP policies prevent using performance-based policies, inefficient regulation of livestock farming and missing incentives to promoting technological developments belong to the identified key weaknesses. The invented novel policy principles and instruments facilitate improving Baltic Sea policies. They provide polluting agents better incentives to protect the sea, to promote environmentally friendly innovations and to engage voluntary citizens to useful work for the Baltics Sea, and sound standpoint to meet the challenges that climate change brings to the Baltic Sea region in a coherence with water policy requirements.

The research community can now provide key solutions to reduce loading and fit the long-term economic growth to the ecological limits of the sea with all stakeholders engaged to determined actions. A Baltic Sea Socioeconomic Action Plan is called for to systematically update and strengthen nutrient policies in the Baltic Sea region countries. As the first steps towards developing this plan we suggest that the following features should be the backbone of such a plan.

1. *Cost-effective abatement with equalization of marginal abatement cost should be the guiding principle of nutrient policies towards point and nonpoint sources, because this principle reflects best the technological and economic possibilities to reduce loads the best.*

2. *Both the EU's Urban Waste Water Directive and HELCOM recommendations are inattentive relative to current abatement possibilities and costs in WWTPs. They should therefore be scaled up accordingly to promote cost-effective abatement.*

3. *The rigid EU CAP policy towards agriculture should be changed to facilitate modern, incentive-based and performance oriented agri-environmental policy instruments instead of the current*

measure-based approach.

4. *Tighter regulation of large livestock farms and promoting industrial scale treatment of manure in the food processing sector provide possibilities for new technological solutions and business opportunities*.

5. *Promoting industrial scale treatment of manure by the vertically integrated the food processing sector would provide one possible solution to farm manure management.*

6. There are ample possibilities to create coherent nutrient and climate mitigation measures in agriculture, which should be utilized.

7. *Regulation must keep pace with economic development and tightening environmental standards by utilizing flexible and innovative instruments, such as nutrient offsets*.

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