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WATER MANAGEMENT FOR AGRICULTURE IN THE NORDIC COUNTRIES

M. BECHMANN, D. COLLENTINE, F. GERTZ, M. GRAVERSGAARD, B. HASLER, J. HELIN, B. JACOBSEN, K. RANKINEN, AND K. REFSGAARD

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AUTHORS

Marianne Bechmann, Dennis Collentine, Flemming Gertz, Morten Graversgaard, Berith Hasler, Janne Helin, Brian Jacobsen, Katri Rankinen and Karen Refsgaard

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APPROVED

JANNES STOLTE

KAREN REFSGAARD

NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

PREFACE

In the NJF-seminar "The water framework and agriculture" 28.-29. October 2015, researchers, representatives from governmental agricultural agencies at local, regional and national level and farmers' advisory services from the Nordic countries participated. The aim of the meeting was to get more insight into the policies and the agricultural management across different natural and institutional contexts through a comparison between the four Nordic countries, Denmark, Sweden, Finland and Norway. The following questions were addressed:

- What policies (instruments and measures) have been used over the last decades in the Nordic countries?
- What is the status of knowledge on management, efficiency and effectiveness
- What is successful water management?
    - How can success be measured?
    - What are the results of the policies?
    - What were the drivers for the measures?
    - Could other measures have been used?
    - Bottom-up or Top-down approach: How have the farmers and advisors been included?
    - What are the challenges to implement measures?
    - Are the policies and the instruments targeted to reach the required abatement?

The present report is based on the seminar and the work done by the authors representing four countries following the seminar. In the report we are focusing on the water quality problems, the policies for implementation of mitigation measures, and the costs and effects of implementing mitigation measures in the four Nordic countries. The authors listed below have written the country-specific chapters in the report.

Norway
Marianne Bechmann, NIBIO – Norwegian Institute of Bioeconomy Research, 1430 Ås, Norway
Karen Refsgaard, NIBIO – Norwegian Institute of Bioeconomy Research, 1430 Ås, Norway

Denmark
Flemming Gertz, SEGES, Agro Food Park 15, Skejby, 8200 Aarhus N, Denmark
Morten Graversgaard, Department of Agroecology, Aarhus University, 8830 Tjele, Denmark
Berit Hasler, Department of Environmental Science, Aarhus University, 4000 Roskilde, Denmark
Brian H. Jacobsen, IFRO, University of Copenhagen , 1958 Frb., Denmark

Sweden
Dennis Collentine, SLU - Swedish University of Agricultural Sciences, Uppsala, Sweden

Finland
Janne Helin, LUKE,00790 Helsinki, Finland
Katri Rankinen, SYKE, 00251 Helsinki, Finland
Kari Koppelmäki, University of Helsinki, Finland

Ås, 10.03.16 *Marianne Bechmann and Karen Refsgaard*

Content

SUMMARY

Water quality

The structure of and the conditions for agricultural production in the four Nordic countries, Norway, Denmark, Sweden and Finland, differ with regard to climate, geology, economic and institutional framework, which influence agronomic practices, economic opportunities and farmers behaviour. Furthermore, there are large differences in water quality problems and therefore concerns for the deterioration of water quality do have different national focus. There are large differences in the problems related to water quality. In Norway and Finland, phosphorus (P) has shown to be the limiting nutrient for eutrophication in lakes and streams and the main policy focus in these two countries are on reduction in P loading. In Denmark, the main problems have been related to nitrate in ground water and eutrophication of the fjords and the coastal areas. Nitrogen (N) has therefore been the focus of the policies in Denmark. During the 1980's and 1990's, however, large efforts have also been made to reduce the P from waste water. In Sweden, the problems of eutrophication are both in fresh water and in the Baltic Sea and as such both policies to reduce N and P have been implemented.

Policy instruments

Despite the differences in natural and institutional conditions between the countries, the agricultural mitigation measures implemented in the four countries have many similarities. For P, the measures include among others management of manure, changed soil tillage, grassed buffer zones along open waters and sedimentation ponds. Measures for reducing N load include among others catch crops, re-establishment and construction of wetlands and management of manure (including among others better storage capacity and livestock density restrictions). Nutrient management planning for N and P are implemented for farmers in all four countries. The advisory services in each country are involved and serve in addition an educational purpose with regards to improved utilization of manure and fertilizer. In Denmark, strong restrictions in N application have been in place, while these restrictions were weaker in the other countries. As part of the Danish government's 16 point plan from 2015, changes in the Danish restrictions are planned.

Although the four countries have much in common, there are also large differences between the instruments used in the agricultural policy. In Denmark, general command-and-control-measures are dominating, whereas more incentive-based policies are used in Finland and Norway with a high degree of regional adaptations.

In Norway, the implementation of mitigation measures consist of general production grants (among others demanding 2-m buffers and nutrient management plan), legislation on manure management and subsidies for e.g. changed soil tillage, grassed buffers and sedimentation ponds administered through the Regional Environmental Program (RMP) and the Special measures in agriculture (SMIL).

The Finnish program for environmental measures is similar to the Norwegian and consists of three different instruments for subsidies, which are both functionally and regionally differentiated. It consists of a basic subsidy, which among others includes maximum N application level and a general requirement for best management practices (good agronomy). In addition, each farm has to choose one or two mitigation

measures, for example catch crops, reduced nutrient application or manure application in the growing season. The third Finnish program comprises specific subsidies which are voluntary for example grassed buffer zones or sedimentation ponds.

In Sweden, implementation of mitigation measures is based on legislations, information campaigns and subsidies. Additionally, a tax on N fertilizer to reduce nutrient losses was introduced in the 1990's and then later in response to political pressure, removed.

Most of the Danish mitigation measures have been implemented as legislations. In 2013, a new law on water planning (Lov om vandplanlægning) which emphasizes the need for a bottom-up approach (e.g. Danish Water Councils based on the Swedish approach) at the local level was adopted, however the implementation remains. The Danish government's 16 point plan from 2015, has the goal of regaining a more competitive Danish agriculture and to do so they are choosing more targeted measures to retain a low loss of nutrient to surface waters. As part of this plan the N-quota, riparian buffer zones, later soil tillage and some other measures is planned to be abolished.

The common agricultural policy (CAP) in EU requires that the EU member states (and Norway), oblige cross compliance for farmers to be eligible for direct payments. This means that in order to receive direct payments and some other forms of support, farmers are required to respect certain rules, including the environmental regulation.

For all four countries most of the measures are within in the Rural Development Programmes (RDP), even though large parts of the Danish agricultural mandatory measures have been outside this programme. Within the RDP, farmers in Denmark, Sweden and Finland can get support for a number of voluntary measures. The RDP program is in Denmark mainly used for support to organic farming, new technology developments, wetlands and set aside and watercourse restoration and maintenance.

Targeting the implementation of mitigation measures

Targeting of mitigation measures to areas where they are most effective will often improve the cost-effectiveness of the measures. In all four countries the focus on targeting of mitigation measures has increased lately. On the other hand, targeting often results in higher transaction costs in the form of administration, advisory service and control. An evaluation of the balance between targeting of mitigation measures and the transaction costs is still lacking. Research shows that knowledge-transfer and involvement in the planning process may result in improved effect and implementation of measures. In each country estimates for cost-effectiveness for agricultural mitigation measures has been calculated.

For comparison between cost-effectiveness of N and P at the catchment scale it is important to take into account that cost-effectiveness should be evaluated according to the reduction targets for the specific recipients, meaning that the cost-effectiveness for different catchments are not directly comparable. Cost-effectiveness of N and P are also not comparable in size due to their different appearance and effects.

In Norway, the cost-effectiveness for changed soil tillage, buffer zones and sedimentation ponds has been evaluated recently by Refsgaard et al. (2013). The results show a large variation in cost-effectiveness mainly due to variation in erosion risk, with the best cost-effectiveness obtained by implementing mitigation measures on high risk areas of erosion. As an example, the cost-effectiveness of all soil tillage changes at erosion risk over 2 tons soil/ha were less than 110 €/kg P. Implementation of spring tillage on soil with erosion risk higher than 0.5 kg soil/ha costs less than 220 €/kg P. Mitigations measures in the agricultural sector were shown to be relatively cheap compared to measures in other sectors, e.g. waste water treatment, but they showed great uncertainty and variation in effect. All in all the research showed that targeting of mitigation measures highly improved their effectiveness.

In Denmark, the level cost-effectiveness of N-measures has been analysed since the 2nd Aquatic programme in 1998 and it has covered both ex-ante and ex-post analyses (Jacobsen, 2014; Jacobsen et al., 2009; Jensen et al., 2009; Eriksen et al., 2014; Hasler et al., 2015). The analyses showed that catch crops and wetlands have been among the most cost-effective measures for many years. The costs for the farmers related to catch crops are in Eriksen et al. (2014) estimated to a level of 1-3 €/kg N (5-19 DKK/kg N) for reduction of N loss to the sea, measured as average costs. If changes in the crop rotation are required to grow catch crops the costs will be higher, in the range 21-32 €/kg N (157-236 DKK/kg N). For wetlands Eriksen et al. (2014) estimate that the costs for the farmers are about 4 €/kg N (31-33 DKK/kg N), when looking at the direct costs for the farmers (financial costs). For comparisons of cost-effectiveness between measures to achieve a reduction target the welfare economic costs are usually reported, being approximately 30% higher. Some analyses of cost-effectiveness with respect to P have also been carried out. Targeting of the measures has shown to improve cost-effectiveness and reduce costs by around 30%. Since 2013, when the Danish Nature and Agricultural Commission proposed that the environmental regulation of agriculture should be more differentiated and targeted, a number of analyses have been made to improve the understanding of the cost-effectiveness of targeting measures. Targeting has been closely linked to a goal of obtaining the largest effectiveness of the measures, and therefore a lot of focus has been given to the differences in N retention in the landscape. Hasler et al. (2015) shows that when assuming differentiated retention, the cost-effectiveness of achieving the WFD target in Limfjorden was 7 €/kg N (costs for farmers obtaining reduction at the sea), while assuming average retention at all fields in the catchment increased the costs to 9 €/kg N. In areas with lower differences in the retention, the difference in cost-effectiveness will be lower (Jacobsen, 2012; Jacobsen, 2014). In 2015 a new retention map was released (Højbjerg et al., 2015), but so far cost-effective distributions of measures using these retention data has not been assessed. It is clear that it is important to find solutions on how to deal with the differences in conditions between farmers, which can be one of the consequences of a targeted regulation.

In Sweden, the use of targeting and evaluation of cost-effectiveness depends to a large degree on whether the measure has been based on legislation, on information campaigns or on subsidies. Measures that have been subject to legislation may be targeted to specific geographical areas (for example restrictions on manure application in areas classified as sensitive under the Nitrates Directive) but these have not been evaluated for cost-effectiveness. The tax on N content of fertilizers was not a targeted measure as it applied to all areas and users. In 1997 the cost-effectiveness of increases in the level of a tax on N leaching were estimated to be 10 - 20 SEK (1-2 €)/kg N for a 15% increase and 15 - 30 SEK (1.5-3 €)/kg N for a 30% increase (Naturvårdsverket, 1997). These costs compared favorably to the most effective subsidy at the time, namely catch crops. The most important information campaign, “Focus on Nutrients” was financed initially through the fertilizer tax and when this was repealed in 2007 by the EU RDP. This campaign was from the start in 2000 targeted at farmers in the three southernmost counties of Sweden (Skåne, Halland and Blekinge), where nutrient losses were considered to be significant. In 2012 the targeted area was expanded to include additional counties and now covers approximately one-third of Sweden. An evaluation of the cost-effectiveness of the advisory program (Agrifood, 2015) calculated the value of a farm visit to be 420 – 8370 SEK (42-840 €) for a kg of reduced N leaching from the advice given while the cost of the visit was estimated to be a little over 23 000 SEK (2300 €).

The primary source of support for individual mitigation measures in Sweden has been through the EU RDP. These measures include direct measures to reduce nutrient losses (catch crops, spring tillage, buffer zones and wetlands) as well as land use measures (extensive ley), which are expected to have a positive effect on nutrient reductions. The first set of measures (catch crops and spring tillage) has been targeted to farms in the southernmost part of Sweden (south of the Dala River) where nutrient losses and areas under cultivation are important. Areas eligible for riparian buffer zones must be along a watercourse and border a minimum area of cultivated farm land. Areas for establishment of ley to reduce nutrient losses have also been targeted to farms in the lower part of Sweden. The cost-effectiveness of each of the measures has been evaluated within the periodic reviews of the RDP (SLU, 2009; SLU, 2010) and a report by the Swedish Board of Agriculture (SJV, 2012). Cost-evaluation of the effectiveness of the riparian buffer zone program has also been performed for all sub-catchments of Sweden (at http://fyrisskz.slu.se). The average cost for N reduction for the two lowest cost measures were 49 – 80 SEK (5-8 €) /kg N for wetlands in 2007-2010) and 96 SEK (10 €)/kg N for combined catch crops and spring tillage in 2008 (SLU, 2010).

In Finland two approaches have been used to produce cost-effectiveness estimates for both N and P. The VIHMA model developed at the Finnish environmental institute (SYKE), generalizes from several Finnish field experiments to estimate the load and impact of different types of measures, while the costs equal the subsidy levels of these measures (Puustinen, 2010). The second approach developed at the Natural Resources Institute (Luke) estimates the costs based on least expensive combinations of measures given the economic data from Finnish farms, while the effect on N and P is derived from the environmental model used in estimating agricultural load from SYKE (Helin, 2013). As both the costs and effectiveness are derived from different sources, the results regarding cost-effectiveness are not identical. Furthermore, the cost-effectiveness of a measure is influenced by catchment characteristics in both of the estimation methods (Helin et al., 2010).

Given the first method, separated estimates for each of the measures are easy to calculate, but are not guaranteed to reflect the least-cost way of reducing the load. Changing tillage is estimated to cost 980-3500 €/ kg particulate P (PP) on flat catchments and 420-660 €/ Kg PP on catchments with somewhat higher elevation differences, while buffer zones cost 970-1700 €/ Kg PP and 70-140 €/ Kg PP, correspondingly. Less spatial information such as the elevation differences have been taken into account in wetland design and hence the costs are more uniform between the different types of catchments (50-60 €/ Kg PP). In Finland, the national target of reduction in P losses from agriculture was set to ca 30%, for which the minimum costs based on the subsidies would be 980 €/Kg PP for flat and 520 €/ Kg PP for steeper fields (Helin, 2013; Helin et al., 2010).

In the second method, the underlying interactions between the effects of measures are not based on expert judgment, but on the process based model ICECREAM. Since, the cost-efficient combination of measures depends on the type of production, maximum capacity and interactions in efficiency between the individual measures, the effectiveness of the measure varies and the costs per reduced kg will depend on the level of the abatement target. The cost-efficient solution for reaching the national target for total phosphorus (TP) varies between 21 €/ha and 354 €/ha. However, these figures are calculated from the baseline with a higher load per hectare than currently observed, because the current policies and farming trends have increased vegetation cover of fields during winter and thus already reduced the PP loads. Further decreases will be more expensive to reach. Moreover, the required measures can change and achieving the target level seems to require establishing wetlands on catchments where erosion control measures on fields have already been implemented if reductions are required in short-time. Since wetlands are expensive, a lucrative longer term solution of reducing the total P load would be to reduce P fertilization and consequently the stock of P in the soil.

The variation in the cost-effectiveness of nitrogen measures in Finland is smaller between the estimation methods, catchments and measures compared to mitigation measures for P. The range is from 7 €/kg N to 85 €/kg with first method and ca 3 €/ha to 84 €/ha for the second method. The low costs are achieved mainly by reduced N fertiliser use. Other measures are more expensive, but many of them also lead to lower P-loads, which might not always be the case for reduction in N fertilisation (Helin, 2013; Helin et al., 2010). In general, the uncertainties related to estimation methods, measures and costs are significant. Using one average number is hardly a reasonable way to describe such results.

Future work

The present report form the basis of further work on evaluating similarities and differences in reductions costs, cost-effectiveness and the success in instrumentation of agricultural mitigation measures in Denmark, Norway, Finland and Sweden. The work need to focus especially on the environmental programmes and the level of subsidies and the uptake of the measures. Furthermore, the future work may look at the extent to which the measures are targeted.

1 INTRODUCTION

The River Basin Management plans (RBMP) and Programme of Measures (PoM) have been adopted in the EU countries and also in Norway. The plans are being implemented according to the planning cycles in the EU Water Framework Directive (WFD). In most countries there is limited knowledge about the costs of the measures and the challenges related to the successfulness of the instrumentation of the implementation of measures. Research shows that legitimacy and knowledge are important for a successful implementation. Further that the costs, effects and farmers adaptation varies with natural and institutional conditions. Therefore better evaluation is needed to calculate costs and effects of the measures as well as analyses of relevant policies to target agricultural pollution.

2 WATER QUALITY PROBLEMS IN RELATION TO AGRICULTURE

2.1 Norway

The status on water quality in Norway is described at the official Norwegian web-page "Environment.no", which is edited by The Norwegian Environment Agency assigned by The Ministry of the Environment. Selected information is presented here.

Inputs of nutrients to coastal waters are steadily rising in most western and northern parts of Norway, whereas the coastal inputs along the Skagerrak have been reduced since 1985. Measurements show that water quality is generally good in more open areas along the Skagerrak coast, but poorer in certain fjords.

The impacts of nutrient inputs are more marked along the Skagerrak coast than anywhere else in Norway. Agriculture and municipal waste water treatment are the main anthropogenic sources of N and P inputs in this area.

Only around 7 percent of Norway's fresh water is characterised as ground water, and accounts for a mere 15 per cent of the water consumption. This is very low compared to many other countries in Europe and is due to the country's abundant supply of surface water.

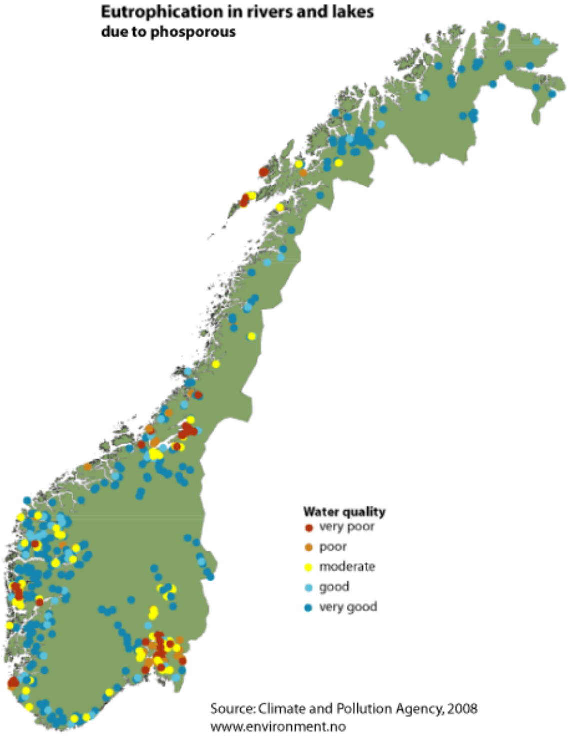


Figure 2.1.1. Eutrophication in rivers and lakes in Norway

The environmental conditions in Norwegian rivers and lakes are relatively good compared with those in most other countries in Europe. A preliminary survey of the status of all Norwegian water bodies shows that around 50 per cent probably will meet the EU objectives for the freshwater environment, while around a quarter are at risk. The rest lacks data or has uncertain status. There are wide regional variations, and not surprisingly, environmental conditions are poorest where the population density is highest. Many rivers and lakes are altered due to hydropower regulations, urbanisation and roads. Furthermore, agriculture is an important source of nutrients in some areas and has been identified as the third most important factor influencing the status of Norwegian fresh water bodies. Despite the introduction of numerous measures in recent years, problems with eutrophication still remain. Environmental monitoring shows that the situation has remained unchanged in the last ten years. Climate change is one probable factor causing increased eutrophication. Most of the eutrophication problems in rivers and lakes are related to P and the measures implemented in Norway are especially focusing on reductions in P loading. The map shows the water quality status in Norwegian rivers and lakes (Figure 2.1.1). In the future, climate change is likely to escalate the problems, particularly with regards to increased runoffs.

Runoff of N and P from farmland causes widespread pollution, and can result in persistent eutrophication problems – with excessive algal and other plant growth and oxygen depletion in river systems and coastal waters. Discharges from silos and slurry stores can give rise to similar problems, but generally on a more local scale. One source of inputs of nutrients from agriculture is the manure and mineral fertiliser applied to arable land and pasture. N is relatively easily leached directly from the soil, whereas most P is bound to soil particles, but can be washed out into river systems and the sea by soil erosion. Other sources of nutrients are leakages from silos, slurry storage systems and milking parlours.

Inputs of nutrients from agriculture have remained almost unchanged over the past ten years. Intensification of agriculture tends to result in higher releases of nutrients. Crop yields are often increased by applying more fertiliser per unit area, and more livestock are kept on the same area of land, making it necessary to apply more manure per unit area. In both cases, nutrient runoff will increase.

2.2 Denmark

Denmark has a long history of introducing water quality policies and management relying on a 30 years history of aquatic action plans aiming at reducing nutrient losses from agriculture and discharge from waste water pollution. Eutrophication, caused by nutrient leakage, is regarded as the major water quality problem in Denmark. Most of the plans adopted in agriculture have focused on reducing N losses and the losses have been reduced by 50% from mid 1980's until now. Some of the key measures used in this period have been quotas for maximum application of N on farm level, improved utilization of nutrients in manure, mandatory catch crops and wetland recreation, and the implementation of these measures have led to a significant improvement of the use of nutrients in manure and a reduction in the use of mineral fertilizer. However, the majority of all streams and lakes and almost all coastal waters are below good ecological status so more effective measures are required to reach this target set in the Water Framework Directive (Figure 2.2.1). Agriculture is an important source of nutrients since 2/3 of the total area is cultivated and hence a large part of the nutrients lost to the water bodies come from farming activities.

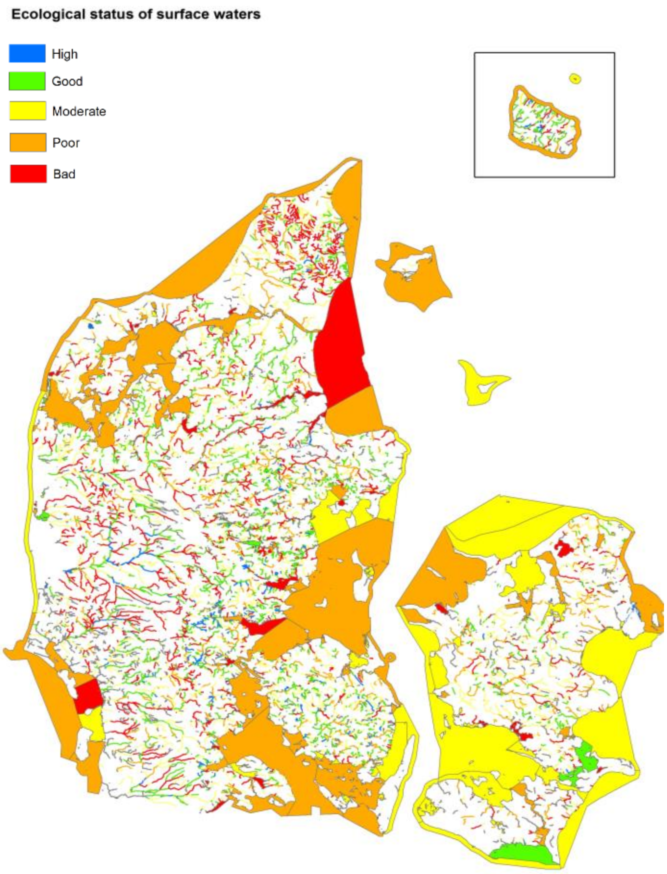
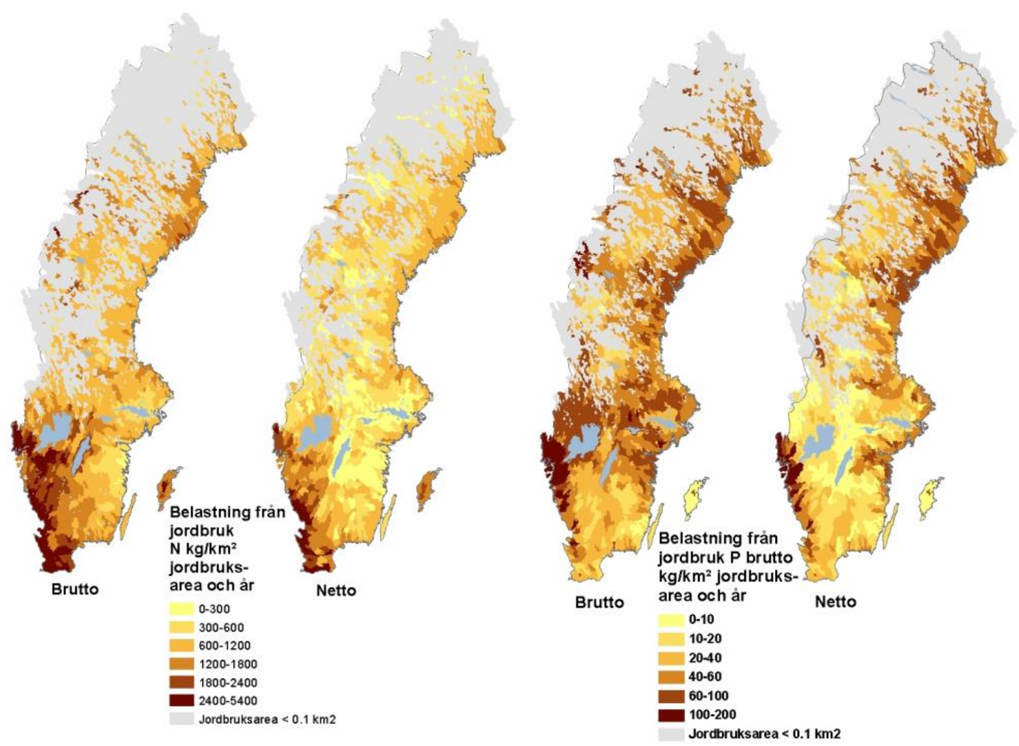


Figure 2.2.1 Ecological status of the Danish surface waters: Streams, Lakes and marine waters (Danish Nature Agency, 2014).

2.3 Sweden

Eutrophication is a problem not only in many inland waters in Sweden but also in the Baltic Sea, where three districts draining to the Baltic Sea are causing eutrophication problems. In Sweden each of the five Swedish Water Districts is responsible for ensuring good water quality status including non-eutrophic status under the European Water Framework Directive (WFD). The Northern Baltic Sea District estimates that around 48% of the water in the district is eutrophic (NBWD, 2008). The Swedish government is also committed as a signatory to the Baltic Sea Action Plan (BSAP) to reduce nutrient loads to the Baltic Sea to achieve good environmental status by 2021 (SNV, 2008). In addition, *No Eutrophication* is one of the 16 environmental quality objectives adopted by the Swedish Parliament. Unfortunately, controlling nutrient losses has been more difficult than anticipated due to the diffuse nature of the loads.



(a) (b)

Figure 2.3.1 Nutrient losses from agriculture in Sweden 2005. (a) Nitrogen (b) Phosphorus Source: Brandt et al. (2008).

Agriculture is the primary source of diffuse nutrient loads to the aquatic environment (Figure 2.3.1). According to a report by the Swedish Environmental Protection Agency (SwEPA, 2009), agricultural practices in 2006 were responsible for 46% of the gross anthropogenic loads of N and P to the environment and around 42% of the net load to the Baltic Sea. Gross anthropogenic N losses from cultivated land in 2005 were estimated to be 49 000 tons and P losses for the same year to be 1 400 tons (Johnsson et al., 2008). While both of these nutrient loss estimates represent improvements over the period from 1995 – 2005 (over which N losses decreased by 14% and P losses by 6.6%) there is still a need for considerable reductions to achieve good water quality status under the Water Framework Directive. The Swedish government commissioned a study to be performed by the Swedish EPA (Naturvårdsverket) and the Swedish Board of Agricultural (Jordbruksverket) to determine how loads of N and P from the agricultural sector could be reduced to meet the targets consistent with the BSAP. The conclusion of this study (SNV, 2008) was that it would not be possible to meet the targets with the set of measures studied.

2.4 Finland

In Finland the recent ecological WFD classification of surface waters showed that rivers and coastal waters need attention in improving their state but larger lakes were mainly in excellent or good state (http://mmm.multiedition.fi/syke/envelope/Envelope_2013_3/sivu_5.php) (Figure 2.4.1.). However, small lakes are suffering from eutrophication and regional differences in the status of waters are considerable.

None of the water areas in coastal regions has high ecological status. The conditions of the Archipelago Sea and of the Gulf of Finland are especially worrying. The ecological status of coastal waters has deteriorated in some parts of the northern region of the Bothnian Bay and the river mouths of the Gulf of Bothnia.

The most significant problem is the eutrophication of waters. Investments in municipal and industrial waste water purification effectively improved the quality of inland waters (Räike et al. 2003). Nowadays water protection policy concentrates on agriculture as it comprises the largest source of nutrients into water bodies. Agricultural land use covers only 9% of the total land area but it is concentrated in the southern and western parts of the country. Earlier increased P fluxes had been observed to cause eutrophication of surface waters as P is the major nutrient controlling eutrophication in many aquatic systems. Later studies have shown that the Baltic Sea may be seasonally or spatially N limited (Tamminen and Andersen, 2007). Further, P is not always the limiting nutrient in lakes either as some smaller lakes may be also N limited (Pietiläinen and Räike, 1999).

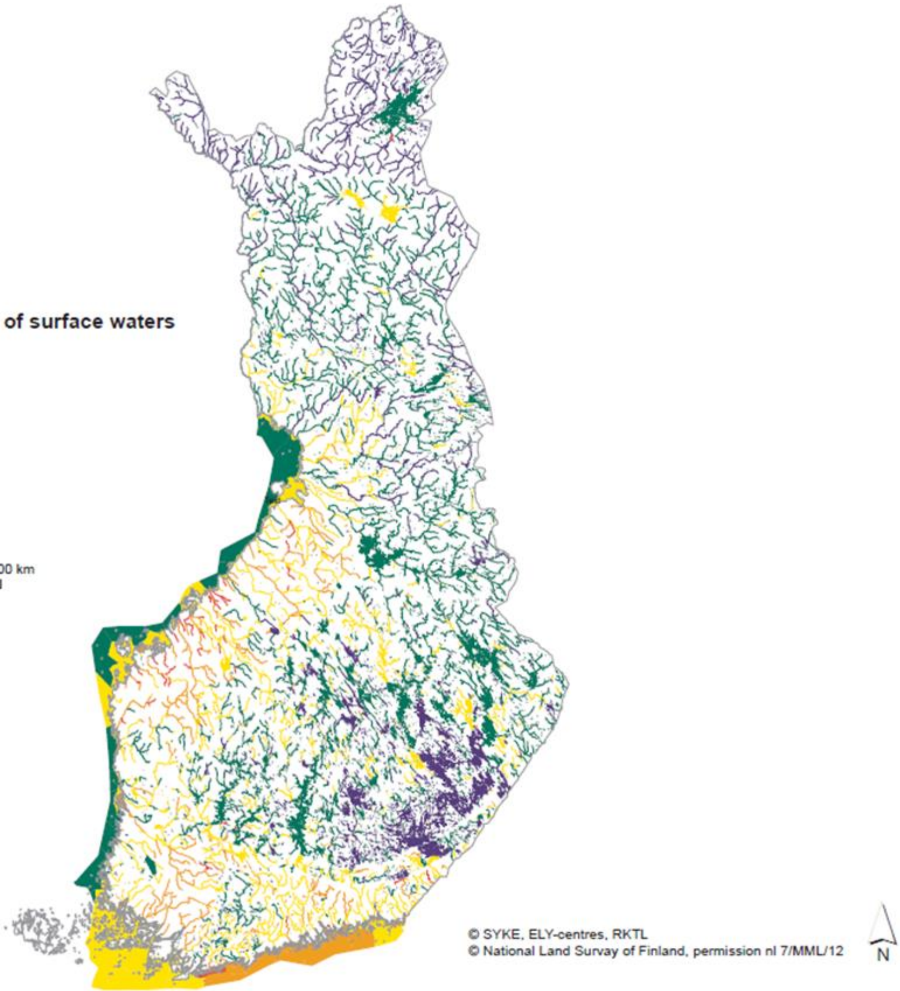


Figure 2.4.1 Ecological status of the Finnish surface waters. http://mmm.multiedition.fi/syke/envelope/kuvat/kuvat_2013_3/Ecological_status_of_surface_waters_2013.pdf.

The flow normalized total nitrogen (TN) flux to the Baltic Sea increased steadily until the period 2000–2006. Turning point occurred around 2000 in the drainage basins of the Gulf of Finland and the Bothnian Sea, and around 2008 in the drainage basin of the Bothnian Bay. Obvious increase in the flow normalized TN flux occurred from late 1990's to mid 2000's. The flow normalized total phosphorus (TP) flux was highest to the Gulf of Finland and to the Bothnian Bay in 1985–1990. Since then the TP flux steadily decreased, exception is the TP flux to the Archipelago Sea which has remained unchanged in 1985-2012.

3 IMPLEMENTATION OF MITIGATION MEASURES

3.1 Norway

3.1.1 Norway's international obligations

Norway is through the EEA-agreement (The European Economic Area Agreement) complying with the WFD and the directive was transposed into the Norwegian regulation as a framework for water management, normally referred to as Vannforskriften (The Water Regulation), entering into force in 2007. Norway has taken full part in the Common Implementation Strategy (CIS) for the WFD since it was established in 2001. Norway performed a voluntary "pilot phase" implementation of the WFD in selected sub-districts across the country from 2007 until 2009, thus gaining the experience on RBMP. River Basin Management Plans for the selected sub-districts in the pilot phase were adopted by the County Councils in 2009, and approved by the national Government in June of 2010. River Basin Management Plans covering the entire country will be prepared from 2010 until 2015, synchronized with the time schedule of the second cycle of implementation in the EU (Vannportalen, 2015).

Norway has undertaken the North Sea Declaration with the obligations to limit or reduce nutrient inputs and the local and central governmental authorities are coordinating efforts to comply with this obligation (Environment.no).

3.1.2 Policy instruments for mitigation measures

During the 1980s and 1990s, a system of regulation and economic instruments was developed to encourage farming practices that would reduce diffuse source runoff from agricultural land and point discharges from silos and manure storage systems. The system has been amended and adapted over the years. The legislation includes various regulations under the Pollution Control Act and the Land Act. There are rules on the levelling of steep and hilly farmland to prevent runoff, and regulations on manure and silage effluent that are intended both to reduce point discharges from storage facilities and runoff after application of organic fertilisers. Arable farmers must carry out a plan for fertiliser application to avoid a surplus of nutrients, and there are rules limiting the number of livestock that may be kept per unit area of land. Furthermore, subsidies are given to soil tillage methods that reduce erosion and to retention-measures for nutrients and soil particles (grassed buffer zones and sedimentation ponds).

The regulations relating to production subsidies include a number of environmental standards farmers must meet to be entitled to the subsidies, including pesticide journal, fertiliser application plan, and two meter buffer zone along water ways. A farmer who does not comply with the requirements may lose part of the production subsidies. The Agricultural Directorate is responsible for the schemes, but they are coordinated by the county authorities.

In addition, there are two systems of subsidies for environmental measures in agriculture to encourage farmers to reduce erosion and P-losses. The one system is meant to solve specific regional environmental challenges (Regional Environmental Programme, RMP) and the other system is for special measures requiring more long term investments and maintenance (SMIL).

In the SMIL system farmers can for example apply for subsidies to establish constructed wetlands or sedimentation ponds, hydrotechnical installations, waste water treatment facilities or re-open culverted streams. Both investment and maintenance may be paid by subsidies. The local county authorities are responsible for these schemes.

In 2005, the agricultural environmental programme was changed from national to regional level, the regional environmental programme for the agricultural sector (RMP). The county governor authorities can adjust measures to suit regional conditions like the agricultural production system, the main environmental problems in the county, i.e. erosion risk and pollution level. Since 2005, the agri-environmental program has been regional in nature, which means that the county governor is responsible for the management of these schemes and have the freedom to choose level of payments, adjust measures and implement new measures. Practices that may be eligible for subsidies include:

- Changed tillage, stubble/minimum-till rather than bare soil during the winter
- Buffer zones along streams and lakes
- Grassed water ways
- Grass on flood areas
- Catch crops
- Manure application in spring and growing season

The priority of these grants varies from county to county, and the county governors are responsible for selection of measures and the level of subsidies.

3.1.3 Level of implementation and effect

Each year Norwegian statistics (SSB) publish time series of statistic information on status and development of agri-environmental issues in Norweigan agriculture (Bye et al., 2015). Selected data and text from this report related to nutrient application, soil tillage and specific mitigation methods is presented here below.

3.1.3.1 Fertilisers and manure

The number of domestic animals, and thereby the quantity of manure and its nutrients, has decreased during the last ten years (Bye et al., 2015). In 2013, the number of animal manure units was calculated to 860 000. An animal manure unit (AMU) is a unit for livestock defined according to the amount of P secreted as excrement and urine (14 kg P/AMU). One calculated animal manure unit is equal to 1 dairy cow, 3 breeding pigs, 7 winter-feed sheep/goats or 80 hens etc. Measured by nutrient content at the national level, 33 per cent of all N and 58 per cent of all P used in the agriculture come from animal manure (Bye et al., 2015). These numbers, however, differ heavily between counties with the least available animal manure in the south-eastern counties.

From 1980 the sales of N have been quite stable, while the sales of P and potassium have decreased significantly, which among others may be due to high rise in prices and changes recommended nutrient application rates. In 2012/2013 the sales of commercial fertilisers were 432 000 tons, about one per cent more than in 2011/2012. The sales of nitrogen were 97 000 tons and the sales of P were 8600 tons. In 2010, the sales of N in fertilizer dropped in Norway due to increased prices (Figure 3.1.1).

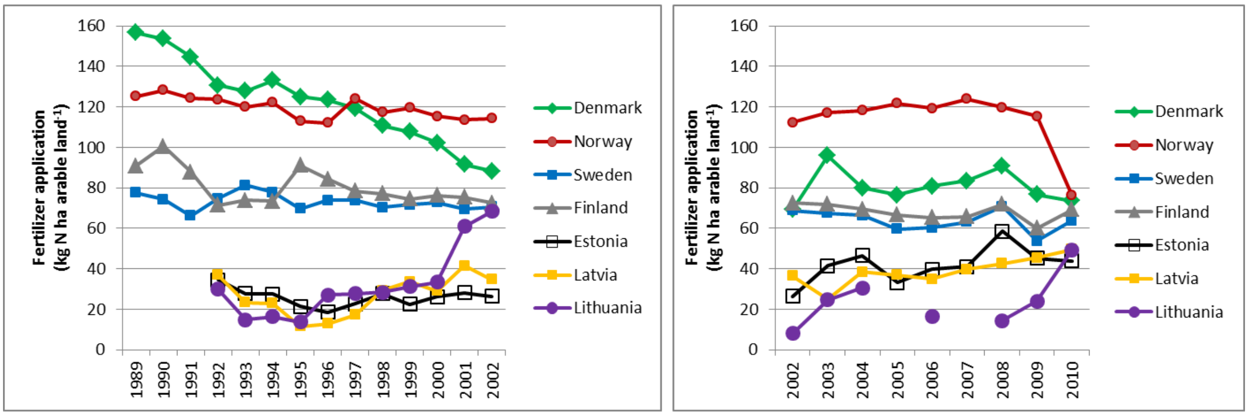


Figure 3.1.1. Sales of N fertiliser in the Nordic-Baltic countries 1989-2010 (FAO; Bechmann et al., 2014).

3.1.3.2 Implementation and effects of measures

The EU WFD divides the country into water regions. The main purpose of the directive is to achieve "good conditions" in all waterways as regards to pollution and ecological conditions.

The county councils within a watershed are Water Region Authorities and they are responsible for the regional management plans including environmental goals and cost indications for the proposed measures for the watershed in focus (Regjeringen, 2015). The plans must be agreed on by the county government and approved by the Ministry of Climate and Environment. Following this the individual measures will be processed in the sector authorities and this includes a more specific evaluation of advantages and disadvantages.

Total contributions of nutrients from Norway to the North Sea are described by Selvik et al. (2015). The size of human discharges of nutrients – P and N – from agricultural activities into the waterways and oceans vary markedly between the different water regions. The water regions Glomma and Vest-Viken are the two regions where agriculture accounts for the largest relative contribution of total losses, 38 and 39 % of P losses, and 41 and 30 % for N respectively. Aquaculture is almost non-existing in these regions. Thus agriculture ranks high in relative contributions of discharges in the south-eastern areas of the country.

In 2013, the area of cereal production constituted 0.30 mil. ha, or 29 % of the total agricultural area in use. Soil tillage methods in cereal areas are highly important for the risk of erosion and the risk of P losses from these areas to the water bodies. Autumn ploughing has been shown to increase both erosion and P losses (Bechmann, 2012). The highest P losses have been registered from winter wheat fields, which are ploughed before drilling, but also autumn ploughing of spring cereals causes the high P losses (Figure 3.1.2).

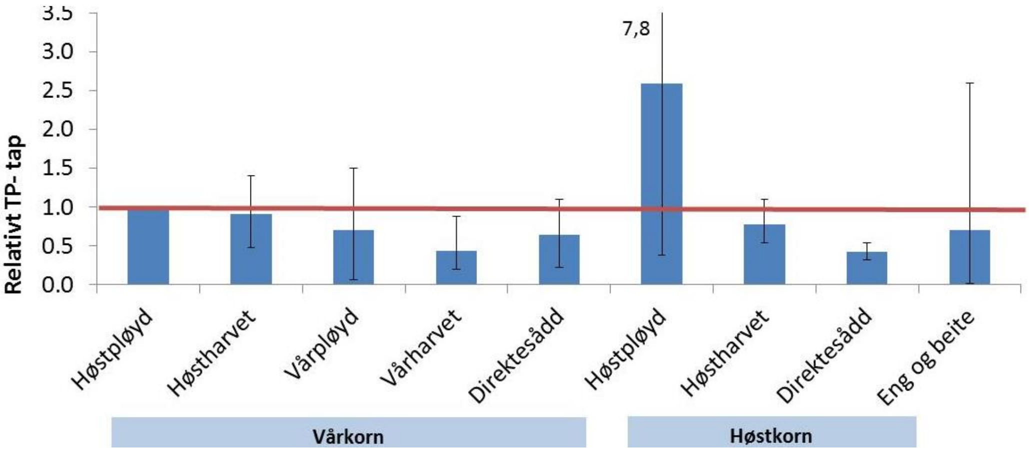
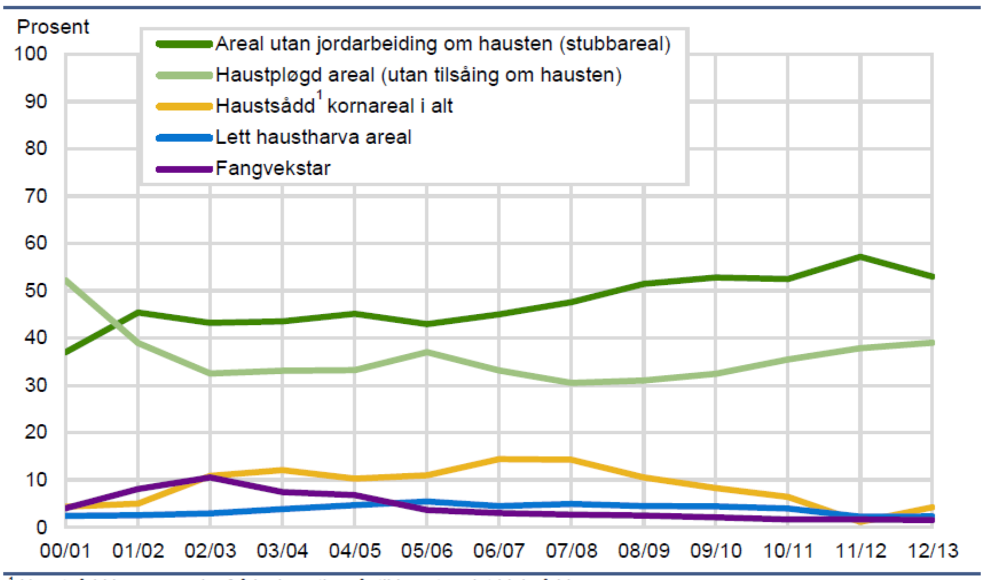


Figure 3.1.2 Effect of different soil tillage methods on phosphorus loss relative to autumn ploughing (Bechmann et al., 2011).

The traditional soil tillage method until 1990 was autumn ploughing. In 2000, the area of cereal ploughed in autumn covered 52% of the total cereal area. In 2013, the area with cereals ploughed in the autumn covered 46% of the total cereal area (ploughed in autumn 2012). Subsidies of NOK 164 mill. were given to changed tillage methods, including catch crops and grassed water ways in 2013 (Regional environmental program) (Figure 3.1.3).



[1] Haustsådd korn er endra frå innhaustingsår til hausten det blei sådd.
Kjelde: Statens landbruksforvaltning og Jordbruksstatistikk, Statistisk sentralbyrå.

Figure 3.1.3 Trends in soil tillage methods (Bye et al., 2015; In Norwegian).

The cereal area which is sown in autumn varies a lot from year to year. If one look at the period 2000-2012, the least area was sown in autumn in 2011 with 1.2% of the cereal area, and the most was autumn-sown in 2006 with 14.4%. For 2013 the number seems to be 4.2% (Figure 3.1.3).
During the period from 1990 to 2002 Norwegian Statistics collected data on soil tillage through "Selected counting's for agriculture". Through this period the autumn ploughed area was reduced from 82% to 43% of the cereal area. Furthermore, it was shown for 2010 that 104 000 ha or a bit less than 34% of the cereal

area was ploughed in the autumn 2009 and had no plant cover during winter. Approx. 6% or 20 000 ha of the cereal area was harrowed in autumn 2010. 86 % of the autumn harrowed area was sown with winter wheat, had catch crops or was covered with plant residues. In total 113 000 ha or 37% of the cereal area had no plant cover during winter 2009/10. Mitigation measures, such as catch crops and grassed water ways received special subsidies from autumn 1991. When the Regional environmental program started in 2005 vegetated buffers were also included in these subsidies. In 2012, subsidies were given for 424 km grassed water ways, 1232 km vegetated buffers and 5770 ha of grassed environmental area. The total subsidies for this were NOK 23.3 mill. The corresponding number for 2005 was NOK 4.1 mill.

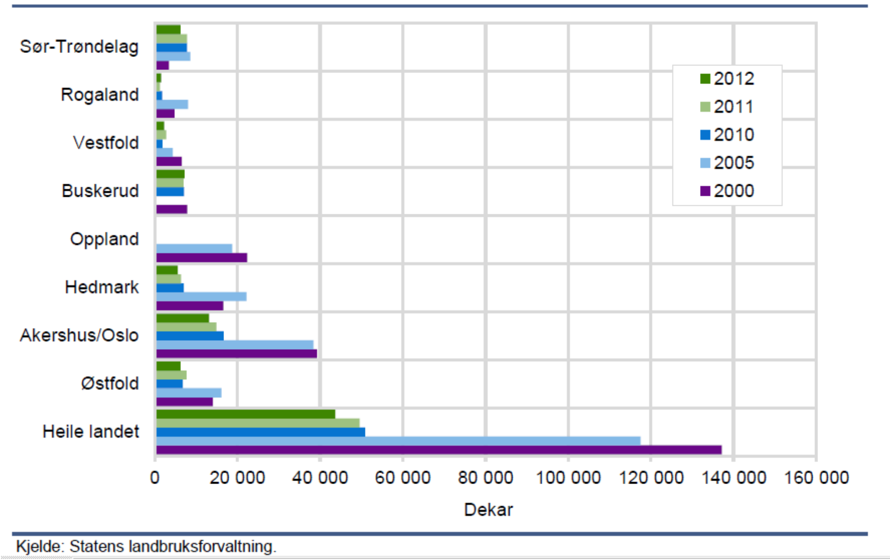


Figure 3.1.4. Trend in area with catch crops for counties and the whole country, 1 dekar = 1/10 ha (Bye et al., 2015; In Norwegian).

The area with catch crops reached its top in 2002 covering in total 35 000 ha with subsidies amounting to NOK 37.7 mill (Figure 3.1.4). Later this area has gradually declined and was in 2012-4400 ha. The amount of subsidies per area decreased simultaneously. In 2012, subsidies were given to catch crop in cereal areas, early potatoes, vegetables and others. The rules for subsidies vary between counties.

In total NOK 67 000 was given to upgrading of 22 sedimentation ponds and constructed wetlands in 2012 (Figure 3.1.5). The county Buskerud had the most with 18 sites for NOK 27 000 in total. In Rogaland county 4 sites received NOK 40 000 in total. Establishment of sedimentation ponds and constructed wetlands are nature based systems to reduce runoff of soil articles and P. Subsidies for establishment of sedimentation ponds and constructed wetlands are part of the SMIL-system. This system was started in 1994 and since then the number of new sedimentation ponds increased, especially from 2000 to 2002 when the number increased from 39 to 100 per year. In 2012, NOK 3.1 mill. was given in subsidies for establishment of 38 new sedimentation ponds and constructed wetlands. During the period from 1994 to 2012 subsidies for in total 941 sedimentation ponds and constructed wetlands has been given. The number is especially high in the Rogaland County. In 2012 subsidies were given for 17 sites in Rogaland and 4 sites in Østfold and Oppland.

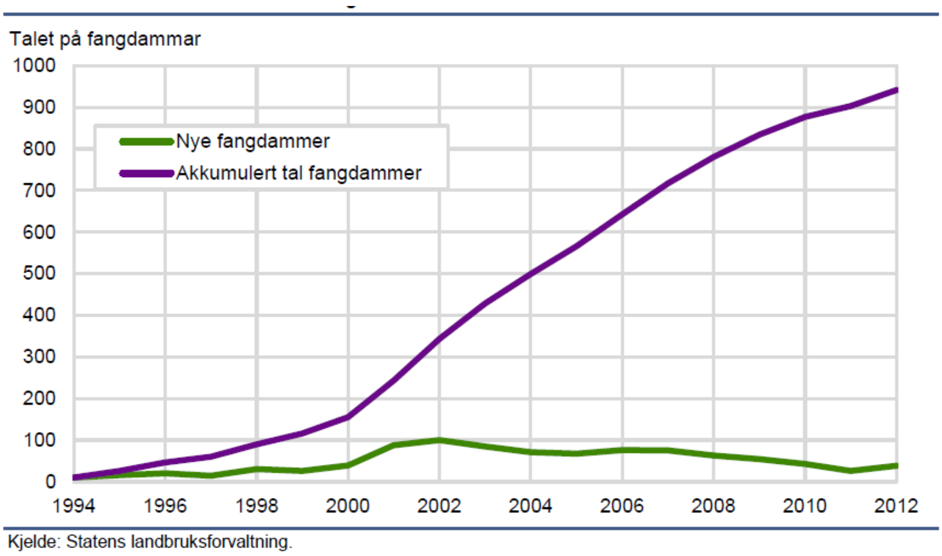


Figure 3.1.5. Trends in number of sedimentation ponds and constructed wetlands (Bye et al., 2015; In Norwegian).

To reduce erosion and nutrient runoff, SMIL-subsidies are also given for hydrotechnical installations. In 2012, NOK 26.8 mill. was given to 592 hydrotechnical installations (Figure 3.1.6). The counties with the most arable land receive the most money for hydrotechnical installations. Akershus county accounted for NOK 8.9 mill. for 172 sites and county Østfold accounted for NOK 5.9 mill. for 127 sites.

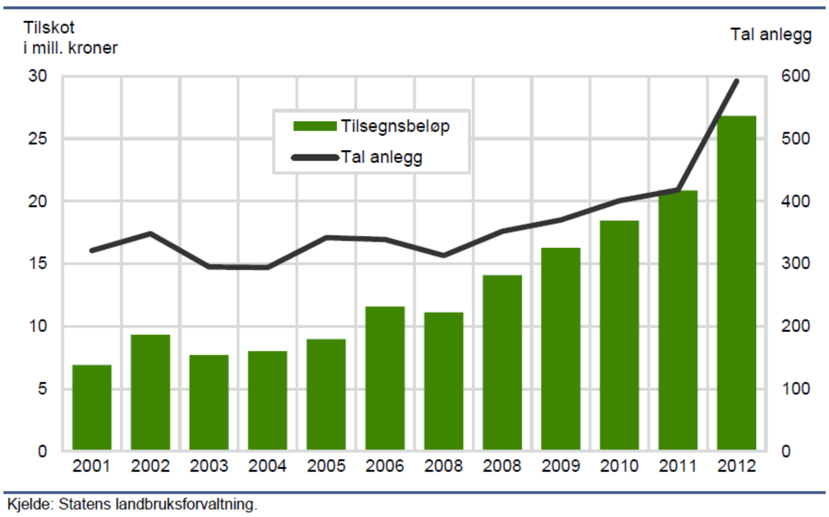


Figure 3.1.6 Improvement of hydrotechnical installations (subsidies and number of sites) (Bye et al., 2015; In Norwegian).

In areas where cereal- and vegetable-production is dominating some of the most important measures are changed tillage, vegetated buffer zones, grassed waterways, catch crops after harvesting, maintenance of sedimentation ponds and in special areas also environmental contracts. Subsidies for these measures are given through the RMP. Subsidies for investment measures such as establishment and maintenance of sedimentation ponds, and hydrotechnical installations were given through SMIL. In 2014 around 205 mill. NOK was given in subsidies to environmental measures shared between 159 mill. NOK through RMP and around 46 mill. NOK through SMIL (Figure 3.1.7). The last years there has been an increase in SMIL measures and from 2010 until 2014 the total subsidies increased from 26 to 46 mill. NOK. Figure 3.1.7 shows the percentage distribution of subsidies within RMP and SMIL for water environmental measures.

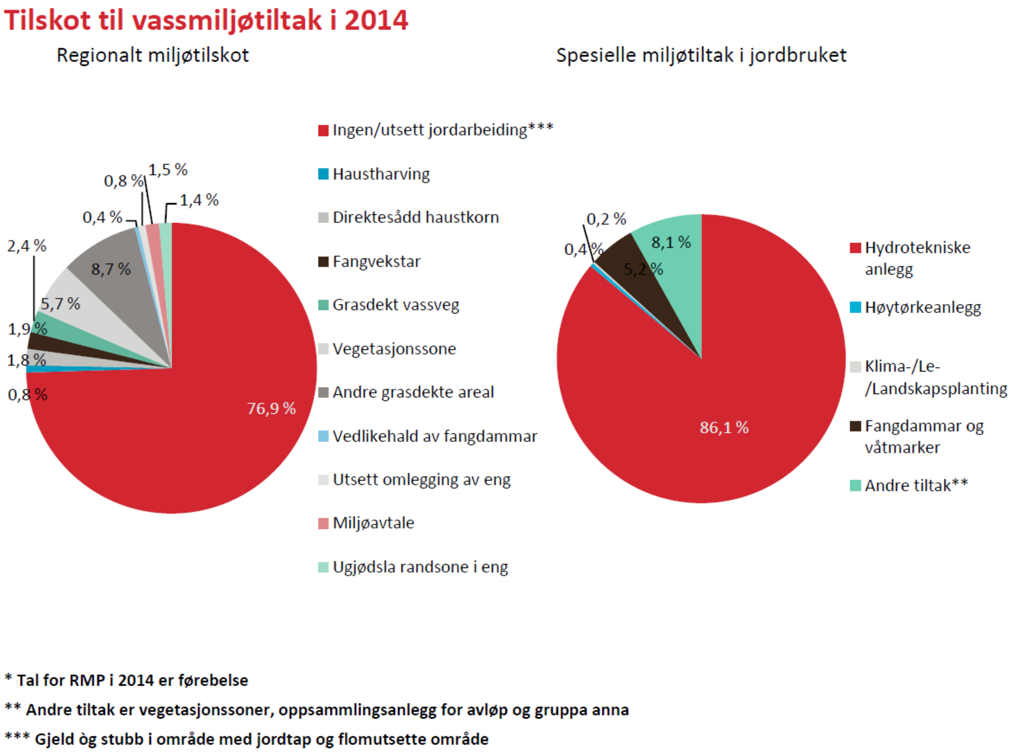


Figure 3.1.7 Distribution of different subsidies (SMIL and RMP) to reduce nutrient runoff from agriculture in 2014 (Trøtscher et al., 2015).

Costs related to changed tillage practice were estimated as the change in farmers' gross margin. An analysis of farmers' gross margins for different tillage practices in different counties in Norway, found that changing tillage most often reduce farmers' gross margin (Refsgaard et al., 2010; 2013), but there are significant variations in these costs. The costs of reducing P losses by 1 kg ranged from NOK 2 000-3 000 on areas with low erosion risk, and NOK 200-300 on land with high erosion risk. As such the subsidies provided for changed tillage on areas with low risk do not cover the costs for the farmers' changed tillage.

3.1.3.3 Cost-effectiveness of measures

The cost-effectiveness of mitigation methods is an important criterion for selection of mitigation methods to be included in the PoM in the WFD. Two studies on the cost-effectiveness of various soil tillage methods for different counties and areas in Norway are analysed in Refsgaard and Bechmann (2015). A key message for policy making was the very large variation in cost-effectiveness due to variation in erosion risk, with the best cost-effectiveness obtained by implementing mitigation measures on high risk areas of erosion (Figure 3.1.8). Furthermore, spring harrowing was found to be the least-cost way to reduce P loss, followed by autumn harrowing and spring ploughing in spring cereals. However, the costs of spring harrowing may not cover the long-term effect on weeds and pests by avoiding ploughing.

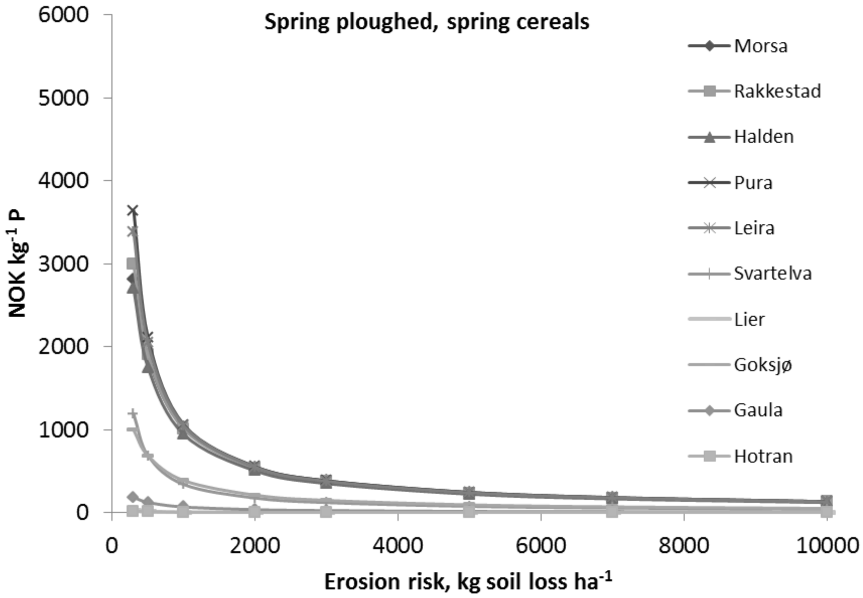


Figure 3.1.8. Cost-effectiveness for spring ploughed compared to autumn ploughed spring cereals for different counties in Norway (Refsgaard and Bechmann, 2015).

Implementation of changed tillage methods was more cost-effective for spring cereals compared to winter wheat. The difference in cost-effectiveness between counties was especially evident for spring harrowing and spring ploughing because of differences in soil type and related agronomic options.

The two studies with surveys of farmers' attitudes and knowledge revealed that farmers demand counselling because of local variations when they decide what measures to implement. Farmers' attitudes and knowledge may be important factors for adopting changed tillage practices. In catchments where there had been a focus on changed tillage practices for several years, farmers' adoption rate of these practices was higher. This suggests that farmers' awareness of this practice affects the rate of adoption. Increased need of pesticides has been related to changed tillage practices. That and other believed or real negative effects may also stop farmers from adopting such practices.

The cost-effectiveness of mitigation methods is an important criterion in water management plans, but when comparing the cost-effectiveness between different sectors, one also needs to consider the differences in forms of P loss. Phosphorus in dissolved form is much more available to algae's compared to particlebound P. The (relative) cost-effectiveness is also affected by variations due to the differences in soil type, agronomic conditions (like machinery equipment), farm structure and labour distribution over the year and socio-economic conditions like alternative income opportunities. The unintended negative impacts on health and environment of changed tillage and of the potential changed use of herbicides and fungicides are aspects that also must be considered in the management and the policy instrumentation. The study by Refsgaard and Bechmann (2015) provides considerable evidence for using local approaches to reduce such pollution from agriculture in a cost-effective way.

3.1.4 Evaluation of the policies for water management

This section is mainly based on Prestvik et al. (2013), Øygarden et al. (2012) and Refsgaard et al. (2013).

3.1.4.1 Reduced tillage and other measures to reduce phosphorus losses

The agri-environmental scheme called "Runoff to water" was evaluated in 2012 by Øygarden et al. (2012). In the report is the design of the instruments, the implementation, the effects and the cost-effect compared for the years 2006 and 2010 and 9 out of 19 counties were analysed, although these were the counties where cereal production are of significant economic importance to farmers and in area. The instruments for these schemes included in 2010 NOK 166.7 mill and NOK 168 mill in 2006. The counties Akershus, Østfold and Buskerud received in 2010 altogether NOK 10.4 mill. more than in 2006 while the other counties had a decrease in use of the subsidies.

In Norway, cultivated area is classified according to erosion risk where category 4 has the highest risk. Measures like changed tillage and conversion to grassland have the highest potential to reduce P losses when implemented on soils with the highest risks of erosion. Payments to farmers are differentiated according to erosion risk, but the level of payment varies between counties and between years.

The evaluation showed that in 2010, 56.3 % of the area used for cereal production in Norway was associated with changed tillage which comprises several tillage practices where the reference practice is ploughing in the autumn after harvest. Changed tillage refers the following practices: harrowing in autumn, direct drilling of winter crops, no till in autumn but ploughing or harrowing in spring and direct drilling in spring. These tillage measures were implemented on a larger area in 2010 than in 2006 in all but two counties. Implementation of other measures, e.g. grassed water ways, grassed buffer zones along streams and areas converted to permanent grassland, also increased from 2006 to 2010. In one county, changed tillage in autumn or conversion to grassland was implemented on all areas with erosion category 3 and 4. In other counties, from 20% to 57% of the area in erosion category 3-4 were ploughed in autumn. From 2006 to 2010, the area of changed tillage in autumn increased the most in erosion category 1 and 2.

The evaluation found no evidence that the differentiation resulted in increased implementation on areas with higher risk of erosion. Size of payment is only one of many factors that affect farmers' decision to implement measures.

Some priority areas have had additional requirements where 60 % of total cultivated area should have no-till in autumn, direct drilling of winter crops or permanent grassland. These requirements of course contributed to a higher rate of implementation of measures than compared to other catchments in the same county. The priority areas have also implemented more measures like buffer zones, grass-covered buffer zones along streams and flood prone areas. Estimated effect on erosion by the changed tillage measures is 290000 tons, which means a 9% decrease in total erosion. The net erosion has decreased in two counties because the total area with no till in autumn has increased. In another county the erosion has decreased due to a change towards implementation of reduced tillage on a larger share of the areas with high risk of erosion. On an overall scale there was a decrease in effectiveness as there was an increase in payments for areas with low erosion risk.

In one very eutrophic area contracts were offered to farmers if they agreed to contribute in several additional practices to reduce phosphorus runoff. These practices included fertilization according to the P-status in the soil, no ploughing in the autumn over a 10-year period while then receiving higher subsidies and dedicated advisory. The evaluation showed that such extra efforts contributed to increased implementation.

According to the evaluation, there is still potential for reduced P load if reducing tillage on areas with a high risk of erosion. However a further implementation of the EU WFD will increase the need for local effective measures especially in areas with high risk of erosion and/or that are particularly sensitive to eutrophication. Furthermore coordination between measures under different programs that can potentially reduce nutrient losses, e.g. changed tillage, fertilizer planning with reductions in applied P and improved utilization of animal manure may be effective measures to reduce P surpluses especially if these are targeted to erosion risk. However also including the farmers' knowledge about his land and possibilities for e.g. grassed waterways, buffer zones etc. in dialogue with the advisory service are promising measures. Reduction in applied fertilizer can also have other positive environmental effects like reduction in nitrous oxide emissions.

With climate change the need for measures to reduce nutrient loads may be increasing, especially with increases in rainfall and higher temperatures that increases risk of erosion.

3.1.4.2 Water governance

When a significant change in water quality is required, the governance of the catchment may be as important as measures and agri-environmental subsidies. The Lake Morsa in south-eastern Norway is an example of how local authorities can team up with stakeholders and return a lake to good ecological status, as is the aim of the WDF (Refsgaard and Gunnarsdottir, 2012). The watershed included 9 municipalities in two counties and served as source of drinking water and recreational area for around 65.000 people. However, heavy loads of P lead to eutrophication and toxic algae blooms. In 1999 the Morsa river basin organization was established and a process of creating trust and collaboration between the stakeholders was started.

The Morsa river basin management team based their water management on knowledge, which led to public understanding and consensus. Objectives were based on analysis carried out by neutral institutes. Every municipality developed a plan for waste water treatment by 2002 and a partly regional and partly municipal environmental program for the agricultural sector came the same year and were adopted by the municipalities in 2003.

The western part of the lake required special measures to reduce P loads. All stakeholders, including farmers were invited to participate in creating an action plan. The solution was a set of environmental contracts between farmers and the county governor in which payments were given to farmers who reduced P application on their fields and implemented other measures. 73 % of farmers signed the contract and total use of P fertilizer was reduced by 75 %. No-till practices were adopted in the autumn, buffer zones were constructed along all streams and 16 wetland sediment traps were constructed. The process changed the farmers' attitudes and engagement in improving water quality.

The result was that the lake again became suitable for swimming in 2008. The result did not come without a cost. In total EUR 90 million were spent on measures, 20 million in the agricultural sector. The area of changed tillage was increased from 30 to 80 percent of the area, P fertilization was reduced by 50 % and around 70 wetlands were constructed. However, good governance of the watershed that created trust, public understanding and collective action were critical factors for implementing the measures that resulted in significantly improved water quality in the lake and rivers.

In a study about the Morsa watershed Stokke (2006) argues that local foundations are one important criterion of success in the Morsa River Basin. Implementing agreed measures would be difficult without the establishment of mutual trust and reciprocity among the different actors in the river basin. In that connection, the Morsa Project has made an important contribution. Establishing shared knowledge has also been crucial, especially to reach consensus about the distribution of costs for the implementation of measures. Even though social capital and institutional capacity is not sufficient fully to explain the collective action, and may not either be sufficient to save Vansjø, these elements have to be at the core of any attempt to achieve results. This is particularly important in this river basin with many dispersed sites of pollution, typical of many persistent environmental problems today (Koontz, 2003; Weale, 1992). At the same time, the study confirms other studies that show that it might be necessary to combine collaborative schemes with more potent mechanisms which reward participation and penalise non-participation (Hovik, 2001; Eckerberg, 1997). However greater central government involvement and more financial means may be necessary to improve the water quality in the lower parts of the watercourse. Implementation of "the polluter pay" principle has made it more complicated to get additional financial means from central government, while some argue that the central government may be responsible for the pollution through the agricultural policy. So there is still a dispute about who is polluting and who is being damaged.

3.1.5 Norwegian summary

The structure of and the conditions for agricultural production in Norway differ with regard to climate, geology, and economic conditions which influence agronomic practices, economic opportunities and farmers behavior. There are large differences in the problems related to water quality within the country, with phosphorus being the limiting nutrient for eutrophication in lakes and streams also resulting in main policy focus reduction in P loading

Most of the eutrophication problems in rivers and lakes are related to P and the measures implemented in Norway are especially focusing on reductions in P loading. The mitigation measures consist of general production subsidies, legislation on manure management and regionalized and localized subsidies for administered through the Regional Environmental Program (RMP) and Special measures in agriculture (SMIL). The agricultural environmental programme was changed from national to regional level in 2005 and administered through the county governor and includes practices like:

- Changed soil tillage, stubble/minimum-till rather than bare soil during the winter
- Buffer zones along streams and lakes
- Grassed water ways and sedimentation ponds
- Grass on flood areas
- Catch crops
- Manure application in spring and growing season

The success-rate for implementation of mitigation measures has been and is high, due to the economic incentives together with knowledge dissemination and in some areas involvement in the processes from advisory service, county governors and water board leaders.

Targeting of mitigation measures often increases the cost-effectiveness of the measures and the targeting mitigation measures has increased lately in Norway. Analyses of cost-effectiveness for changed soil tillage, buffer zones and sedimentation ponds showed a large variation in cost-effectiveness mainly due to variation in erosion risk, with the best cost-effectiveness obtained by implementing mitigation measures on high risk areas of erosion. On the other hand, targeting often result in higher transaction costs in the form of administration, advisory service and control. An evaluation of the balance between targeting of mitigation measures and the transaction costs is still lacking. Research in Norway also shows that knowledge-transfer and involvement in the planning process may result in improved implementation of measures. Mitigations measures in the agricultural sector were shown to be relatively cheap compared to measures in other sectors, but also with uncertainty about the effect. However the research showed that targeting measures is very important to achieve a high effectiveness.

3.2 Denmark

The focus in the Danish environmental policies related to agricultural impact of water quality has been on reducing N losses (leakage at the root zone, emissions to air via stables) and to achieve better water quality and later with the implementation of WFD to achieve good ecological status in the water bodies. This chapter describes the Danish regulation from the mid 80'es to now, implemented by the Aquatic action plans and the WFD. Both the action plans and the WFD implementation have been supported by intensive research programmes documenting the potential effect of measures and the implementation in the agricultural production, as well as by a well-established and efficient agricultural advisory service.

3.2.1 The Aquatic action plans (1987-2005)

The first Aquatic action plan was agreed on in 1987, following up on the "NPO" statement report from 1984. The objective of the Aquatic action plan was to reduce the diffuse N-leakage at the root zone by 50% and P-losses from point sources by 80%. These targets were retained in the second and third Aquatic action plans from 1998 and 2004. The reductions in P losses were mainly achieved by large investments in waste water treatment plants and by reducing other point sources from industry. This regulation was effective and gave an immediate effect, but was also perceived as relatively costly (2,000 million per year for industry and sewage plants with more than 100 DKK/kg N) (Finansministeriet, 2001; Jacobsen et al., 2004). The costs has been distributed to Danish tax payers via the tax on water use and discharges. The N reduction measures where mainly targeted to agriculture, but since agricultural loads come from diffuse sources which are more difficult to regulate, with a time lag from the measure is implemented to the effect can be measured, the effect has taken much longer time. After the implementation of the three aquatic plans the target of 50% reduction has been reached (Mikkelsen et al., 2009; Dalgaard et al., 2014; Jacobsen et al., 2004).

One of the key policies implemented in both of the Aquatic action plans is related to regulation of N application. The N application is regulated by N-norms or quotas that set a limit for the N applied to the specific crops grown. This N-norm includes both mineral fertilizer and the organic manure. The requirement regarding the utilization of N in manure, the manure N efficiency, is one of the highest in EU (Webb et al., 2010 (page 7)). The Aquatic action plan II from 1998 reduced the N-norms to 10% below the economic optimum based on yield response and prices. Due to changes in the optimal level the application rate is currently 18% under the economic optimum for 2014/15. The implication is that the shadow price of N is now exceeding the price of N, meaning that the farmers face incentives for a high utilization of N in animal manure. This is also supported by an obligatory requirement of N budgets and accounts. The average Danish farm use around 145 kg N (effective) / ha of which 80 kg N/ha comes from mineral fertilizer and the rest from animal manure. The use on mineral fertilizer is shown in Figure 3.2.1 where the drop since the beginning of the 90'es is clear.

Currently each Danish livestock holding must ensure a balance between agricultural land and the number of livestock units corresponding to a maximum of 170 kg ha^{-1} yr^{-1} of N from manure for cattle holdings and 140 kg ha-1 yr-1 of N for all other livestock holdings, which is stricter than the standard requirements of 170 kg N/ha from manure in the Nitrate Directive (Mikkelsen et al., 2010). This has kept the livestock density in Denmark at 1.1 Livestock Units (LU) per hectare, which is somewhat lower than the livestock density in other livestock intensive areas in EU (Grinsven et al., 2012). One Danish livestock unit is defined at a level of 100 kg N, measured at the storage level, and it is currently equal to 0.75 dairy cow or 4.3 sows with piglets up to 7 kg. Compared to most other EU-countries a large share of the total area is used for intensive agricultural production. Figure 3.2.2 shows the total N application and the increasing N-efficiency over time. The effect comes from a slight decrease in inputs and an increase in production.

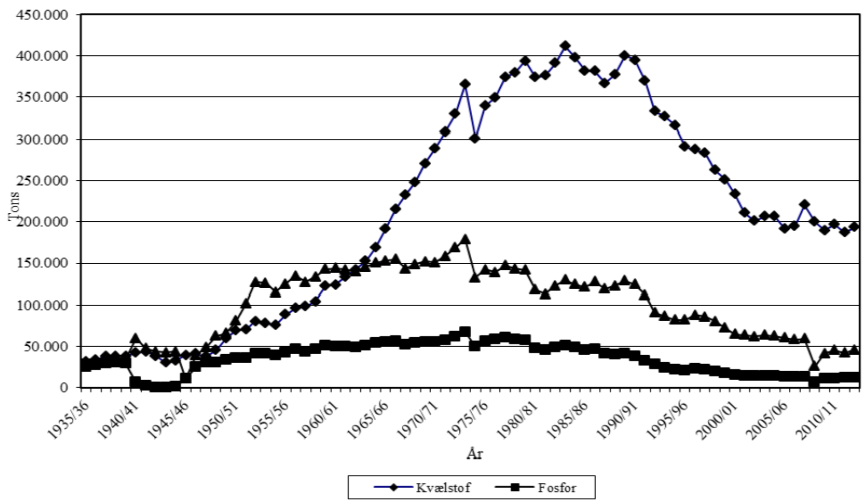


Figure 3.2.1. The purchase of nitrogen and phosphorus in mineral fertilizer from 1935 until 2012/13. Source: NaturErhvervsstyrelsen.

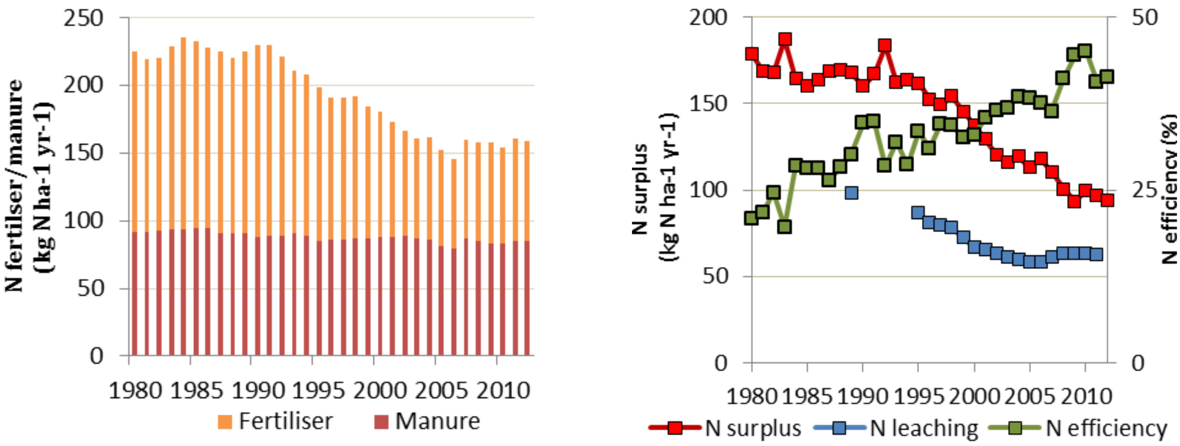


Figure 3.2.2. Average consumption of mineral fertiliser and manure (left). N surplus, N efficiency and N leaching (right) for the agricultural area in Denmark, 1980-2012 (Blicher-Mathiesen et al., 2015).

The total costs of the Danish aquatic action plans have since the mid 1990'es had focus on cost-effectiveness of reaching the selected targets. These targets have primarily focused on N-losses and to some degree also the P surplus. The overall costs of all the action plans so far (including agricultural and non-agricultural measures) are around €600 million (2005 prices) (Jacobsen et al., 2004). Of these the annual cost related to agricultural measures is about €340 million, and the rest is related to industry and sewage treatment plants. The estimated costs related to the different action plans are described in Table 3.2.1. Roughly half of the costs are paid by the agricultural sector and the rest by the state, municipalities and EU. The Industry has paid most of the costs related their improved waste water treatment.

Table 3.2.1. Estimated costs of agricultural measures in different action plans to reduce N leaching from agriculture (2005 prices)

	Reduced N-leaching from rootzone Tons N per year / kg N/ha/yr. (ex ante)	Ex-ante costs (mill. €/year)	Ex-post costs (mill. €/year)
Action Plan for aquatic environment I – API (1987)	50.000 / 19	84	Not calculated
Action Plan for a more sustainable agriculture (1991)	40.000 / 15	134	Not calculated
Action Plan II (1998 – 2003)	48.000 / 18	92	70
Action Plan III (2004-2012)	300 / 1	30	48
Total	**150.000 / 53**	**340**	---

Source : Jacobsen et al. (2004), Jacobsen (2004), Jacobsen et al. (2009), Jensen et al. (2009).

The payment of the costs in APII has been roughly evenly divided between the agricultural sector and public funding. There seems to be a tendency for the agricultural sector to pay for farm-related measures (changed production), whereas the state pays for land taken out of production through measures which are co-financed with the EU. In terms of farm types, the majority of costs, which relate to measures like changes in feeding, lower livestock density and increased utilization of N, are borne by animal farms, whereas other costs (lower N quota and catch crops) are more evenly divided among farms (Table 3.2.2).

Table 3.2.2. Cost effectiveness for different measures in Action Plan II.

	Reduction in N leaching (Tonne N/year)	Total cost (Million €/year)	Cost effectiveness (€ / kg N)
Wetlands	800	0.7[3)]	0.9
ESA-areas[4)]	700	7.7	10.9
Forestry	800	4.7[3)]	5.9
Organic farming	3,700	14.0	3.8
Changed feeding	3,800	5.7	1.5
Lower livestock density [1)]	140	1.5	10.4
Catch crops (6 pct.)	3,000	6.4	2.1
Increased utilization of N in animal manure (15 pct.) [1)]	10,110	6.7	0.7
Reduced N quota (10 pct.) [1) 4)]	12,850	22.8	1.8
Sum [2)]	35,900	70.2	2.0

[1)] In the technical evaluation of Action Plan II the effect of these measures was not estimated individually, hence the figures given here are approximate estimates.
[2)] Changes in use of area and animal production as well as other matters are not included in the table.
[3)] Annuity based on 4 percent interest and infinite lifetime.
[4)] ESA are Environmental Sensitive Areas
[4)] A later recalculations have shown that the costs of N-norms have been higher than expected. (Kristensen and Jacobsen, 2014).
Source: Jacobsen (2004).

3.2.2 The WFD and the River Basin management Plans from 2011

The action plans have been followed up by the implementation of the WFD, where the objectives have been changed from a reduction target on N and P at the root zone, to environmental objectives of obtaining good ecological status, as in the rest of the EU and EØS countries (EU Commission, 2002). The Danish River Basin Management Plans (RBMP) are the implementation of the WFD in Denmark for the first period and describe both the present water quality, the distance to good ecological status and the measures implemented in the first planning period in the 23 catchments (Dalgaard et al., 2014). The quality evaluation show that only 28% of the streams, 22% of the lakes and 2% of the coastal waters have Good Ecological status and by 2021 this will be 54%, 44% and 42% with the current baseline projection (DØRS, 2015). More measures are needed to reach the targets by 2027.

The annual costs of the RBMP from 2011 have been estimated to be 56.6 million € (Jacobsen, 2012). The cost of reducing the diffuse pollution from agriculture is 35 million € a year and the rest are costs to implement groundwater measures, to improve the physical conditions in streams and point source pollution. In 2012 the costs for the agricultural sector was estimated to 18 million € per year, which is somewhat higher than the expected 11 million € per year when the RBMP plans were made, due to higher costs related to the implementation of catch crops, change in norms and the ploughing of grass for feeding.

3.2.3 Measures and N-policies 2014 until today

When looking back over the years some key measures have already been highlighted such as the N-norms and the reduction to under optimal N-norms. These general regulations have reduced N-losses, but have also been costly. The costs have been relatively high for many farms as the N-norm is set according to crops, soil type and use of irrigation. As mentioned the combination with N-accounts and the requirements on utilization of N in animal manure has promoted high utilization of N in manure. The catch crops are another well used measure, which many farmers do not believe have the desired effect especially on clay soils. Today all farms have between 10-14% catch crops and some more if it is part of an increase in the livestock production.

With respect to the area related measures where area is taken out of production, wetlands and riparian zones have been discussed for many years in Denmark. Riparian zones were previously voluntary, but the area was very limited. Then in 2012 the 10 m (later 9m) riparian zones were made obligatory along all streams. The implementation turned out to cause a lot of protest among the farmers because of faulty maps associated with the decision, and the opposition against the measure led to that this measure will be abolished from 2016, although the measure has positive effects in relation to N, P, pesticides and nature aspects, if targeted to the riparian zones.

Wetland reconstruction is another example of a measure which has been implemented over many years based on co-operation between farmers and authorities, and between farmers. The first projects were implemented in 1990'ties and the total area is today over 12,000 ha. The implementation of the measure has shown large differences in costs and effects (Hansen et al., 2011), and has, among other factors, given rise to the increased focus on targeting the nutrient regulation to areas where the measures are most cost-effective.

The Danish government's 16 point plan from 2015, has the goal of regaining a more competitive Danish agriculture and to do so they are choosing more targeted measures to retain a low loss of nutrient to surface waters. As part of this plan the N-norms, riparian zones and some other measures have been abolished.

A number of analyses and model assessment have been made to elucidate the effects of a more targeted regulation as an alternative to the more uniform regulation being used until now. Hasler et al. (2015) made an assessment for the Danish Economic Council in 2015, comparing the costs and effects of uniform and targeted implementation of nitrogen load reductions to the fjord 'Limfjorden'. Hasler et al. (2015) analysed the effects of targeting the measures in the subcatchments of Limfjorden. They used the modelled and measured retention and compared with a scenario with average retentions in the catchment. Hasler et al. (2015) found that the marginal cost of N reductions with average retention is 131 DKK (17 €)/kg N, while the marginal cost with the modelled targeted retention for the catchment is 91 DKK (12 €)/kg N. The interpretation of this result is that including retention in targeted regulation is important, as this can lead to a large reduction in the costs. This targeting will direct the abatement to the areas where the effects at the coast will be largest, and avoid abatement at sites where the effects are low. Other national analyses have also shown an economic gain of 20-25% from targeting of measures (Jacobsen, 2012; Jacobsen, 2014). There is a large variation in the economic gain from targeting as the advantage is highest in catchments with large variation in the retention. Studies on targeting at the farm or field level indicate a need to use new estimations of retention in order to reduce the uncertainty at the farm or field scale. The analyses in the NICA project has shown a large variation in the possible economic gain from targeting at the farm level (Jacobsen and Hansen, 2016). The reason is that both the variation in retention and the management options vary from farm to farm. Not all farmers can therefore locate the measures (e.g. catch crops) on the fields with the largest effect every year.

3.2.4 Danish water councils - a new bottom-up approach to RBMP

Most of the measures applied in Danish water management have until now been focused on command-and-control measures, mainly to ensure the effect as the voluntary measures have often not had the required effect (Dalgaard et al., 2014). With the introduction of the WFD a focus on participation of stakeholders has been put forward with an emphasis on an increased attention on the need to find new approaches with local, targeted measures (Nature and Agriculture commission, 2013). The first Danish RBMPs should have been implemented in 2009, but were firstly published in December 2014. There had been protests against the planned measures that led to a 5 year delay of the first RBMPs. The plans had over 5000 complaints and many of the main interest groups and the public weren't involved in the process. This has proven to be problematic for the Danish implementation of the first cycle of RBMP (Gertz et al., 2012). Because of the struggle with the first RBMPs, the government decided in preparing the second RBMP (2015-2021) to adopt a new bottom-up participation concept. In 2013, the former Danish government adopted a new act on water planning (Lov om vandplanlægning) (FT nr. 1606 26/12/2013). This new act on water planning allowed for a new bottom-up water management concept with the establishment of 23 water councils in all 23 River Basin Districts. The water councils were to advise the local municipalities on applying PoMs for the improvement of the physical conditions in targeted Danish streams. This was mainly done to ensure a greater local involvement of stakeholders in the 2. cycle of River Basin Management Plans. In an evaluation study of the water council work in 2014, this new approach has been tested and found successful in finding solutions at the local level (Graversgaard et al., 2015; Graversgaard et al., 2016). The evaluation study found that the concept created legitimacy around creating PoMs and that the possibility of knowledge co-production was responsible for the process-success of this new kind of institutional arrangement and water management (Graversgaard et al., unpublished material). The question is, if the use of water councils in water policies in general would have created PoMs that would have been more cost-effective than the chosen measures and would they have managed to reach the goals?

The targets required to reach good ecological status in Denmark has been translated into a reduction of N which is required. There is much debate on these calculations and the required target. In the RBMPs from 2014 it was estimated that a further 9,000 tons of N should be reduced on top of the baseline development (Jacobsen, 2014). In 2014 a new catalogue of measures was prepared with the aim to provide a basis for choosing the most cost-effective measures (Eriksen et al., 2014). Focus in the catalogue is on the new measures as well as the most important ones, but even if there is a focus on targeted and local measures the estimates in the catalogue are still showing average measures of costs and effects, even though both costs and effects differs a lot between locations. At the same time work has been initiated to investigate new regulation paradigms to obtain more local and targeted regulation, and a new N retention map has been established (Højbjerg et al., 2015) to enable localisation of measures to the areas where the N retention is lowest, i.e. where the effect of the measure in the fjord or coastal area will be the highest possible. The new regulation paradigm, as well as the use of the retention maps, has not yet been decided on politically.

Farmers are currently most interested in measures like constructed wetlands (ponds, mini-wetlands), early sowing of winter wheat and other measures outside the farm area, such as mussel farming, compensating farming to remove N in fjords. Nature organizations are on the other hand suggesting that more area should be taken out of production to reduce N-losses and improve water quality as well as nature and biodiversity.

3.2.5 Conclusion and discussion - Denmark

It is evident that the N regulation of Danish agriculture has had a significant measurable statistical impact on the decreasing trend in N surplus, in N leaching from the root zone, reduction of nitrate in groundwater, and on the N load to coastal waters. The measures applied have succeeded in improved utilization of animal manure, fertilizer and crop rotation plans, improved utilization of feed-stuffs and on limitations on the total N application. Important factors is the knowledge-based approach with intensive research programmes documenting the potential effect of measures and the successful implementation of measures to the Danish farmers by a well-established and efficient agricultural advisory service. Cost-effectiveness has been an important focus area for many years. The N norms and the N accounting system has both reduced inputs and improved utilization of N in manure. What we also see is that these measures have a limit. Documented significant and continuous lowering of protein content in Danish cereal have been the price for low N Norms over a number of years and the new government's 16 point plan, is part of regaining a more competitive Danish agriculture and on the other hand choosing more targeted measures to retain a low loss of nutrient to surface waters. Therefore the future regulation is focused on trying to target the measures to areas where the effect in terms of reducing the N loads to coastal waters are the highest. Including this aspect means more targeted measures at selected locations and will give economic gains as oppose to not targeted measures. The regulatory setup to deal with this has not been decided yet.

3.3 Sweden

3.3.1 Policy

The Swedish Parliament in 1988 decided that a PoMs was to be initiated which would reduce the loss of nutrients from agriculture to the environment. There were three broad types of measures introduced to reduce nutrient losses from agricultural production; regulations, informational measures and measures supported by economic instruments. The decision was also specific with respect to the measures that were to be included in the program; manure storage capacity requirements, limited animal intensity, fees on mineral N and P, requirements for green cover during fall and winter and provision of advising to support plant demand fertilization. Initially the PoM was driven by national environmental goals and included in national agricultural policy. Since agri-environmental policy was motivated by national interests the only obligation was to achieve Swedish national political commitments and satisfy national politicians and voters. However, membership in the EU and subsequent international agreements changed this obligation through a series of directives and treaties.

Swedish membership in the EU allowed for financing of agri-environmental measures through the EU Rural Development Program (RDP) but also required compliance with two EU Directives; the Nitrates Directive (ND) in 1996 and the WFD in 2000. In addition, as a signer of the agreement on program to reduce nutrient loads to the Baltic Sea (Baltic Sea Action Plan) Sweden committed itself to a set of quotas which specified national loads for each of the countries participating in the agreement. However, in spite of these latter commitments Swedish agri-environmental policy measures continued to have national goals as the factor which motivated their existence. These goals had been codified by the Swedish Parliament in 1990 as a set of 16 national environmental goals (Miljömål) which included several with respect to water quality. The most important of these for the impact of agriculture with respect to nutrient losses was the goal of "zero eutrophication". Although there were additional goals which were included to motivate agri-environmental measures that would reduce nutrient loads from agricultural; flourishing lakes and streams, good quality groundwater, flourishing, a balanced marine environment, flourishing coastal areas and archipelagos, thriving wetlands and a rich diversity of plant and animal life. What is perhaps worth noting is that in the subsequent Swedish RDPs (for 2000-2006 and 2007-20013), in the descriptions of goals associated with payments for agri-environmental measures that aim at reducing nutrient losses, there were only references to the national environmental objectives. No specific reference was made to the role these measures would have for achieving compliance with the WFD or the BSAP.

3.3.2 Measures

In addition to the regulations which addressed manure handling, the other two types of measures either provided payments to landowners (farmers) for adopting practices which could reduce nutrient losses or imposed a fee on the use of mineral fertilizers. The subsidized measures were included in the RDP while the fee system was national. In addition, funding has also been provided through government sponsored co-financing of individual local water management projects (LOVA program).

3.3.3 The tax on mineral fertilizers

The initial fees on mineral fertilizers were transformed into a tax on mineral N in the mid 1990's. Politically the taxes were not popular with the party which represented rural (farming) interests, the Center Party. In 2009 the tax was removed as part of an agreement which included higher taxes on the use of diesel fuels. At the time the tax was rescinded it was suggested that removal would have an insignificant impact on N losses. However, it was recognized that without the tax a lower price would result in a greater level with respect to the rate of economic optimal application and thereby higher leaching. The Board of Agriculture estimated that removing the tax would result in an extra 1500 tons of gross N losses and increase in loads to the sea of 900 tons. The so called insignificance of the effect was also questioned in a comment from researchers to the Board of Agriculture where it was pointed out that the reduction provided by the tax was almost equal to the reduction by most effective agri-environmental measure, cover crops (see Table 3.3.1). The tax was however repealed. Unfortunately, no measures to counteract this increase in leaching were implemented.

Some of the revenue from the tax had been used to support advisory services provided through a project, "Focus on Nutrients" jointly managed by the Board of Agriculture and the National Farmer's Organization (LRF). When the tax was repealed funding for this program was instead included as a measure under the RDP.

Table 3.3.1. Reduced N and P loads as a result of measures in place and technological development.

Measure	Reduction in N load	Reduction in P load

	Gross	Net to sea	Gross	Net to sea
RDP supported measures				
Focus on Nutrients	650	390	10	7
Cover crops and spring tillage	600	375		
Wetlands	450	300		
Controlled drainage	30	22		
Riparian buffer zones			12,5	6,5
In-field wetlands	100	50	8	5
Regulations				
Manure spreading Fall and Winter	280	193		
Manure spreading along watercourses	30	20	2	1,5
Technological development				
Techniques for adjusted N applications	450	300		
Reduced tillage	375	250		
Application of biogas waste	180	120		
Total	**3145**	**2020**	**32,5**	**20**

3.3.4 Agri-environmental measures in the Rural Development Programme (2000-2013)

In addition to support for the advisory program “Focus on Nutrients” included in the RDP starting in 2007-2013, other individual activities have been supported in both 2000 – 2006 and 2007 – 2013 which are expected to lead to reduced nutrient losses. The measures are quite detailed and included the following measures with a primary focus to reduce nutrient losses:

- Cover crops
- Spring tillage
- Riparian buffer zones
- Wetlands
- Extensive ley cultivation
- Controlled drainage (RDP starting in 2010)
- Buffer zones on erosion sensitive lands (RDP starting in 2010)
- Small wetlands as P traps (RDP starting in 2010).

3.3.5 Effect and implementation

It is somewhat difficult to consistently discuss the effect of the measures due to difficulties in measurement. The effect of some of the measures is either expressed as reduction in losses on fields at the root zone level (cover crops, spring tillage, ley, controlled drainage, in field buffer zones and wetlands) and sometimes at the interface with the aquatic environment (riparian buffer zones, wetlands). The root zone estimates may not express accurate reduction due to transport time lags (groundwater, drainage water or surface runoff) and vary greatly due to soil and weather types. The effects of riparian buffer zones and wetlands are very site sensitive and in the case of wetlands, design sensitive. The effects are also categorized as gross (aggregated sum of the local effect of the measures) or net (includes a factor to account for retention between the local effect and discharge to the sea). The extensive and large area of inland lakes in Sweden and act as a sink for nutrients which means that location of some of the measures will have a large local effect which is important for compliance with the quality standards of the WFD but may have a small net effect on the sea and the nutrient load quotas of the BSAP.

In 2008 the Swedish government gave an assignment to the Board of Agriculture to develop a plan of action for reducing the loss of nutrients to the environment for the period from 2011-2016 with a focus on outcomes to the year 2020. The final study report (SJV, 2010a) included an analysis of the effect of measures expected to be in place for this period as well as proposals for additional measures which if adopted could also be effective. Table 3.3.1 below reproduces the estimated reductions from the appendix to this report (SJV, 2010b). In Table 3.3.1 the estimated gross reductions from all current measures are 3145 tons of N and 32.5 tons of P with more than half of this coming from measures supported by the RDP.

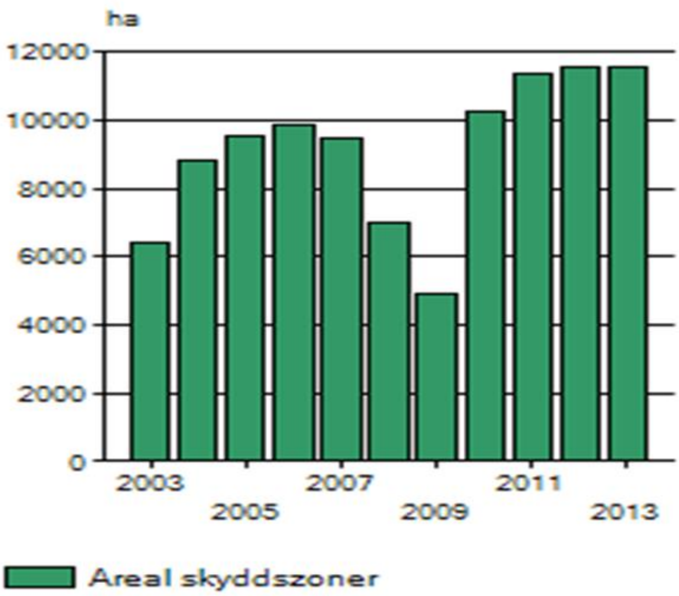


Figure 3.3.1 Area with buffer zones in Sweden in the RDP 2003-2013.

Implementation for some of the measures has varied over time, others have been relatively constant, some undersubscribed, some oversubscribed. The area in riparian buffer zones dipped significantly in 2008, a trend which continued into 2009 before surpassing previous levels in 2010 (Figure 3.3.1). The explanation for the dip and subsequent recovery were the significantly lower payments in the RDP program starting in 2008 (1000 SEK (100 €) /ha) compared to the previous period (3000 SEK (300 €)/ha) before the payment was raised in 2010. The operative goal for RDP enrollment was 5500 ha for the period from 2000-2006. This goal was exceeded for all the six years of the program, in 2006 there were 9080 ha enrolled (160% of the goal).

There are three practices which fall under the title of “reduced N leaching” cover crops, spring tillage and a combination of these two (Figure 3.3.2). Participation in all three of these follows a similar pattern from 2000-2013. First rising when support for these measures was introduced in 2000 to more than 200 000 ha before falling steadily for a couple of years and stabilizing at around 150 000 ha. The operative goal for the measures in the first LBP period were that 50 000 ha would either have cover crops and/or be spring tilled. While this operative goal was considerably exceeded (358%) there was still a potential for increasing the area. In a study over the potential of these activities to meet BSAP targets, Johnsson et al. (2009) estimated that there were 593 000 ha which could be included in the program, with 368 000 ha of this on lighter soils with a higher reduction potential although a large share of the lighter soils was already enrolled in the program in 2005 (around 50%) while only 10% of the area with heavier (clay) soils was in the program that year.

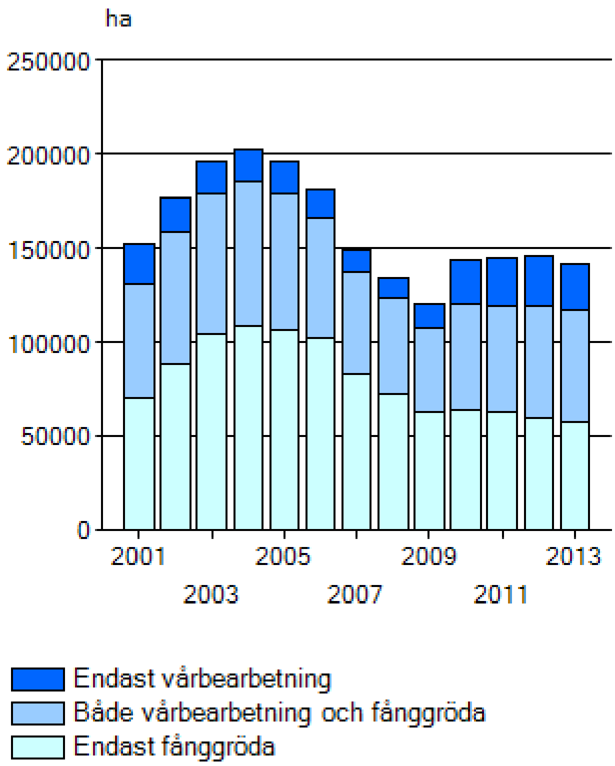


Figure 3.3.2 Area with different soil management and catch crop in Sweden. Endast vårbearbetning = only spring tillage; Både vårbearbetning och catch crop = both spring tillage and catch crop; Endast fanggrøda=only catch crop

The area in wetlands was supported by two types of financing; RDP and Local Investment Program (LIP). The operative goal was for 6 000 ha of wetlands to be maintained or created in the first and second LBP periods. Up through 2006 there were 3 868 ha which received program support (65% of the goal). More than two-thirds of the wetlands receiving support were small (less than 2 ha). There was also support provided for extensive ley production. The operative goal for the second LBP period was 200 000 ha, a goal which was exceeded for 2007 – 2010 by around 30 000 ha each year. The Focus on Nutrients program over the period from the start in 2001 to 2012 reached out to around 8200 farm enterprises.

Although no direct comparison exists for the meaures described above and the RBMPs, four measures with the potential for reducing P loads, currently supported in the RDP have been singled out by the three southern Swedish river basin districts in their Programs of Measure (Larsson, 2012)):

- Small constructed wetlands for P retention (800 ha)
- Larger constructed wetlands (13 000 ha)
- Permanent grassed buffer strips (28 000 ha)
- Cover crops and spring cultivation (93 000 ha)

The same study reported that in the Northern Baltic Sea river basin district the total effect of the measures directed to agriculture is estimated to reduce gross P loads by 45 tons and gross N loads by 107 tons.

3.3.6 Measure effects and cost effectiveness

The effects of some of the measures (cover crops, spring plowing, riparian buffer zones) are based on the same models used for reporting on a regular basis (every six years) as part of the Helcom Pollution Load Compilations (PLC). These reports in turn serve as guidelines for goals and targets in both River Basin Management plans and Baltic Sea Action plan (BSAP). Therefore there is a consistency between the effects reported and the goals for these measures. The effects of wetlands on reducing nutrient losses have been the subject of an in-depth study performed for the Board of Agriculture (SJV Rapport 2010:21). These effects were also the basis for the half-time evaluation of the RDP covering the period from 2007 – 2010. The effect of the support for extensive ley is taken from information provided in the half-time evaluation. The effect of the Focus on Nutrient program is based on a recent independent evaluation of the program performed by the Agrifood Economic Center (2015).

Additional measures not included below because they are new and fewer studies of their effects have been performed. These include: structural liming, in field wetlands, in field buffer zones, controlled drainage, precision agriculture, two-stage ditches and lime filters.

3.3.6.1 Cover crops and spring plowing

The total area of the three measures included under this heading (cover crops, spring plowing and a combination of the two) were estimated in 2009 to lead to a total reduction of 1 340 tons N/yr. The average annual reduction was 9.8 kg N/ha for the area in the RDP support program. However, the estimated reduction varied across the areas of support from a low of 5.6 kg N/ha in Eastern Sweden (south of Stockholm) to 12.9 kg N/ha in the area with a lot of rain and erodible soils but with less areas eligible for support (Western Sweden). Cost effectiveness was calculated in the half-time report for the three measures by using the modeled estimates for the effects and the payments made to support each of the measures (as subsidy per hectare was different for each measure). The average cost for N reduction for the three measures in 2008 was 96 SEK (10 €)/kg N. This represents a fall in average costs with respect to the average for the previous LBP period when the cost was estimated at 115 SEK (11 €) /kg. The improvement in cost effectiveness may have been due to lower participation in the program in 2008 compared with the previous period due to an adjustment in support payments. The RDP from 2007-2010 included increased support for cover crops in combination with spring plowing (the most effective of the three measures) and lowered the payments for cover crops with fall plowing (the least effective measure).

3.3.6.2 Riparian buffer zones

In 2008 the area of riparian buffer zones supported with payments from the RDP was estimated to lead to a reduction of 6.5 tons of P. This results in a reduction of 0.93 kg P/ha with respect to the total hectares supported in the program. However, almost half of the total was due to commitments entered into in the previous period. Landowners who participate in the support commit to keep a buffer zone maintained for 5 years. In the new LBP the payments were lowered from 3 000 SEK (300 €)/ha to 1 000 SEK (100 €) which not only led to a sharp fall in the area signed up in the new program but also increased the cost effectiveness of the measure. In the previous program the P reduction was calculated at 3 250 SEK (325 €) /kg while in the new program with the same effect but lower costs the reduction cost was only 1020 SEK (102 €) /kg.

A new web based program, the FyrisSKZ, summarizes the cost efficiency of buffer zones along lakes, watercourses and ditches for all 12,864 sub-catchment areas of Sweden. FyrisSKZ is a public domain web application (at http://fyrisskz.slu.se) which allows users to choose one or several sub-catchments from a GIS interface and view the estimated reduction of a buffer zone on P losses to the watercourse from surrounding fields, the opportunity and maintenance costs for buffer zones, and the potential area of buffer zones in the chosen sub-catchment. These estimates are presented for five individual buffer zone widths to allow the user to study the influence of the selected width on the reduction effect, costs and potential area. An application of the model (Collentine et al., 2014) demonstrates how the model makes it possible for local authorities to raise cost efficiency through better targeting.

3.3.6.3 Wetlands

The estimated N retention of wetlands that received support from the LBP for the period from 2007-2010 varied between 49-80 kg N/ha of the support area. The estimated net load to the sea was reduced by 36-77 kg N/ha. The result then for the 747 hectares built with support over this period was between 37-60 tons N/yr. The area of LBP support is somewhat larger than the area of the wetland as it may also include surrounding areas which are affected by the wetland and which are therefore eligible for support. If the actual wetland surface area instead of the LBP supported area is used to calculate the effect, the effectiveness is doubled in size. P retention for the same period and same wetlands was estimated to vary between 0.96-5.05 kg P/ha resulting in a total reduction of 0.7-3.8 tons P/yr.

3.3.6.4 Extensive ley

This measure in the RDP consists of two separate objectives. One part of the measure targets forested areas of Sweden with the goal of increasing biodiversity. The second objective is to increase the area in ley in the most agriculturally intensive areas of Sweden with the goal of reducing nutrient losses. Evaluating the effect of the support payments on both objectives has proved to be difficult as the payments primarily serve to keep the land already cultivated in ley in that land use. If the payments were not present it is not apparent what the land would be used for and therefore difficult to assign an effect. If the measure results in less land lying fallow than it is expected that this can be considered positive with respect to reducing nutrient losses but has not been quantified.

3.3.6.5 Focus on nutrients

In 2008 the Board of Agriculture performed an evaluation of the effect of the Focus on Nutrients program on N losses on farms that participated in the advising program (Olofsson et al., 2008). The report concluded that farms in the area where the program had been active the longest (since 2001) the area of cover crops in participating farms was 2-4% greater than the average for all farms in the area. According to the report authors there was a greater level of participation in the cover crop measures for Focus on Nutrient farms than for other non-participating farms. A more recent report (Agrifoods, 2015) the authors concluded that increased advising visits from the Focus on Nutrients program reduced N leaching and led to increased yields. The report also compared the cost of the program with the reductions and gains in yields. Each advising visit was estimated to reduce N farm surpluses by 3.6 kg/ha of which 2,12 kg/ha was attributed to the advice provided through the program and after taking into account leaching as a share of the reduced surplus and retention led to a reduction to the sea of 0,89 kg/ha. On the basis of other studies this reduction was valued at between 4.1 – 81.8 SEK (0.4-8 €) /kg. With the average farm size within the program of 115 ha this led to a value of the reduction of between 420-8370 SEK (42-840 €) per program advising visit. In 2013 the program cost 440 million SEK (44 mill €) which gave a cost of 23 400 SEK (2340 €) for each farm visit. However, the effect on increased yield values from the visit was estimated at almost 36 000 SEK (3600 €) which more than covers the cost of the visit.

3.3.7 Swedish summary

Environmental policy in Sweden to address problems with nutrient losses from agriculture in Sweden has followed three pathways; regulations, informational measures and economic incentives for farmers. Policy was initially driven by national environmental objectives (Miljömål) and subsequently by the need to comply with EU Directives (Nitrate, Water Framework and Marine Directives) and an international agreement, the Baltic Sea Action Plan (BSAP). However, measures taken in Sweden along all three pathways are still currently more focused on meeting the national objectives rather than fulfilling the goals of the international drivers.

Regulations have been introduced to codify good agricultural practices, primarily with respect to manure handling. Informational measures have been promoted and supported through a project “Focus on Nutrients” jointly managed by the Swedish Board of Agriculture and the National Farmer’s Organization (LRF). The project was initially financed through a part of the revenues provided by a tax on the nitrogen content of mineral fertilizers. When this tax was removed in 2009 financing of the project was continued with funds provided through the EU Rural Development Program (RDP). Although the nitrogen tax was estimated to have reduced losses by 1500 tons (900 tons to the Baltic Sea) when it was removed there was no introduction of new measures to compensate for the expected increase in N loads. This was significant as the effect of the tax represented almost half of the reductions of all other measures supported through the RDP.

The RDP is the primary source of providing economic incentives for farmers to adopt nutrient mitigation measures. The first two RDP programmes (2000-2006 and 2007-2013) included among others support for catch crops, riparian buffer zones, wetlands and ley crops. These particular measures were motivated to meet the national environmental objective of “No Eutrophication”. While the current RDP has not yet (December 2015) been finalized it includes support for these measures in some form as well as expected support for a limited set of new measures. Although the RDP provides the only source of financing for achieving water quality goals with respect to nutrients, correspondence between the goals of the new RDP supported measures and the EU Water Framework Directive (WFD) and BSAP are not well established.

3.4 Finland

3.4.1 Introduction to Water protection policies of agriculture in Finland 1995-2015

This section describes the change in Finnish agriculture’s water protection policies and measures. The policies are analyzed from the perspective of their objectives, coherence, evidence base, compliance, reference payment levels and evaluation. OECD (2012) provides an overview of these policy aspects.

3.4.2 Objectives and Coherence

The objectives of Finnish water protection policy are formed by national implementation of the EU directives and international commitments such as the Helsinki convention for the protection of the Baltic Sea. In addition there are national strategies and targets such as “Guidelines for water protection for 2015”. However, the most important measures for non-point pollution control fall under Rural Development programme and more specifically under the agri-environmental scheme of the programme.

Prior joining to the EU, Finland had no scheme on reducing environmental impacts of agriculture. Voluntary environmental protection measures at farms were possible, but agricultural subsidies were targeted on increasing production. Even the objective of the fertilization taxation (1976-1994) and obligatory set-aside has been considered to be the financing of subsidies and cutting of over-production caused by crop price subsidies, rather than, or at least not solely, the water quality (Aakkula, 2006).

Objectives of the first agri-environmental subsidy scheme after Finland’s EU membership were related to sustainable agriculture, with focus on water quality and biodiversity. Maybe not so obvious for the public, the agri-environmental scheme was also an instrument of income subsidy for the farmers (Aakkula, 2006). Possibly related to this dualism between the goals of the scheme, the objectives were set at a highly general level and without specific targets regarding the quality of the water, for example a measurable range of concentrations in rivers or lakes was not used. Originally, implementing the agri-environmental scheme was assumed to reduce suspended sediment and thus also nutrient losses into water bodies by about 20–40% (Valpasvuo-Jaatinen et al., 1997).

At the more general level of water protection policy, governed by Ministry of Environment, a quantifiable target of halving the N and P loads to both inland waters and sea was set for 2005. While this government approved guideline contained more specific measures such as reduction of erosion from fields with technical solutions, improved nutrient management and handling of manure, the measures themselves did not have target levels, and the practical implementation of reaching the targets by policy intervention was left rather for the Ministry of Agriculture and Forestry, which was in charge of the agri-environmental subsidy scheme. In the Rural Development programme, there were targets for measures in general terms such as reduction in erosion, but not their impacts on water quality.

A new Rural Development programme of Finland was approved by the European Commission in 2000. Its objectives included reducing environmental load and sustaining agricultural production. These objectives, including production, were repeated for the agri-environmental scheme of 2000-2006. More specifically it was stated that in the longer run, measures in agri-environmental subsidy would cut down N and P loads by 50% from the levels of 1990s. Water Framework Directive (WFD), which came into force in 2000, is not mentioned in the Rural Development Programme or later in the interim report of the Ministry of Agriculture and Foresty concerning the implementation of the agri-environmental scheme (Wallenius & Kauranne 2003), while several pages are dedicated to economic outlook of the Finnish farmers. Within WFD, the agri-environmental scheme is considered as the main tool to control nutrient load from agricultural areas. Alas, conclusions of another interim report (Silvo et al., 2002) by Finnish environment institute regarding the insufficient performance of measures relative to the targets seem to have made no mark in the agricultural policy domain.

Common Agricultural Policy (CAP) was reformed in 2000, resulting to several changes in the Finnish agricultural policy, but the objectives of the Finnish agri-environmental scheme remained generally unchanged even in the following programme period of 2007-2014. Similarly, the changes to national legislation for implementing WFD that were approved in 2004 were not explicitly accounted for in the revised agri-environmental scheme.

As the previous target year of 2005 for national water protection guidelines passed without reaching its objectives, a new set of targets for water protection was set for 2015 (VN, 2006). The targeted reduction levels were also decreased. The cut in the level of nutrient loads to water was aimed to be one-third of the load levels of 2001-2005. Still no specific performance targets were defined for the measures of the scheme.

As expected, Finland adopted water management plans with the overall objective of good ecological status (Mäenpää & Tolonen, 2011). To support implementation of these plans quantitative targets for number of specific measures were set by government (VN 2011).

CAP revision of “Agenda 2000” and the CAP “Health Check” agreed in the EU in 2008 were detaching further subsidies from production and introducing cross compliance requirements for good farming practices. From environmental perspective these changes improved the coherency of the main CAP income element with the agri-environmental part. However, many national subsidies in Finland were still allocated based on cultivated crops, conflicting with the aims to reduce nutrient loads in the agri-environmental scheme. The CAP “Health Check” also abolished the minimum requirements for fallow.

3.4.3 Reference level for payments, implementation and compliance

The EU membership introduced more stringent environmental regulation in Finland. Both Nitrate and Water Framework Directive were considerable changes to the national agricultural water protection policies. However, the cross compliance requirements for good agricultural practice concern a wider range of production conditions than the Nitrate directive, which focuses on N. WFD is not directly influencing the reference level at all. Thus, the reference level for which the agri-environmental measures are to be compensated is rather dependent on CAP instead of the other policies.

Due to a high participation rate in the agri-environmental subsidy scheme the effect of cross compliance is not as much in directly changing the farmers' practices, as changing the agri-environmental subsidy scheme. For example non-cultivated strips at field edges were part of the good farming practice, and due to the cross compliance they became part of the reference level for which farmers would not be entitled to compensation in the agri-environmental scheme. The revised subsidy is calculated based on the area which exceeds the good farming practice requirement given by width of 0.6 meters in contrast to 1-3 meters required in the agri-environmental scheme depending on the type of stream, ditch or lake the field is located next to.

Similarly, for N the reference level for which the compensation depends on is set by the Nitrate directive, which is applied in the whole of Finland. The reference level itself is public, but the details of the levels of compensation are taken within the Ministry of Agriculture and Forestry. These reference level calculations have not been published, but they have been subject to an approval by the commission of the European Union and nationally influenced by various stakeholder groups that participate in the committees drafting the agri-environmental scheme.

The Finnish agri-environmental scheme was built on three types of subsidies that were both regionally and functionally differentiated. The first element was the largest one in subsidy volume and a precondition for farmers to access the other two elements that were containing most of the measures of the scheme. The first element, labelled "basic subsidy", contained maximum allowed fertilisation levels differentiated between crop and soil types as well as general compliance with good farming practice, which was later adopted from the scheme to the CAP cross compliance requirements. The basic subsidy also included information dissemination in the form of farmer training and monitoring. The second element, entitled "additional measures", was containing options from which the farmers would have been required to choose between two to four measures. The third element was called "specific subsidy" and contained measures that were completely optional and also harder to implement in the subsidy per year per hectare (of farm size) -frame, which was applied for the other two elements.

Additional measures and the fertiliser use limits were tweaked between the agri-environmental schemes, but the basic composition remained intact until the revised scheme of the latest Rural Development Programme (2014-2017). Additional measures included further adjustments to fertilisation, increasing vegetation cover of farm land during winter, cultivation of catch crops, diversification of farming, extensive grass cultivation and manure application during the growing season. The third element contained establishing of vegetated buffer zones and wetlands, as well as, ground water area specific cultivation, treatment of runoff water, organic production and production of indigenous species or traditional biotopes.

More significant than the change in the measures was the change from different farm size classes in the first programme to only one size class in the following programmes, which implicitly established an income subsidy within the agri-environmental scheme. As agri-environmental subsidies are calculated based on an average farm size and contain several fixed cost elements that do not scale up with the farm size, the bigger farms profit (and smaller farms lose out) even though the subsidy as a whole would be income neutral. If the subsidy level is set so that even the smallest farm is fully compensated, the rest of the farms gain an income subsidy. Having several size classes meant that bigger farms were not overcompensated as much as with a scheme having a single size class.

Throughout the existence of the scheme, the participation rates have been high, nearly 90% of the farms. However, the farmer compliance has not been monitored in any of the impact assessment and monitoring reports of the scheme (Palva et al., 2001, Turtola and Lemola, 2008, Aakkula and Leppänen, 2014). The agri-environmental scheme was enforced as a part of the overall CAP compliance checks in which 5% of the farms were inspected. There is no public record of compliance. The committee set by the Ministry of Agriculture and Forestry considered added efforts in monitoring and enforcement as non-recommended extra burden for farmers (Wallenius and Kaurannne, 2003).

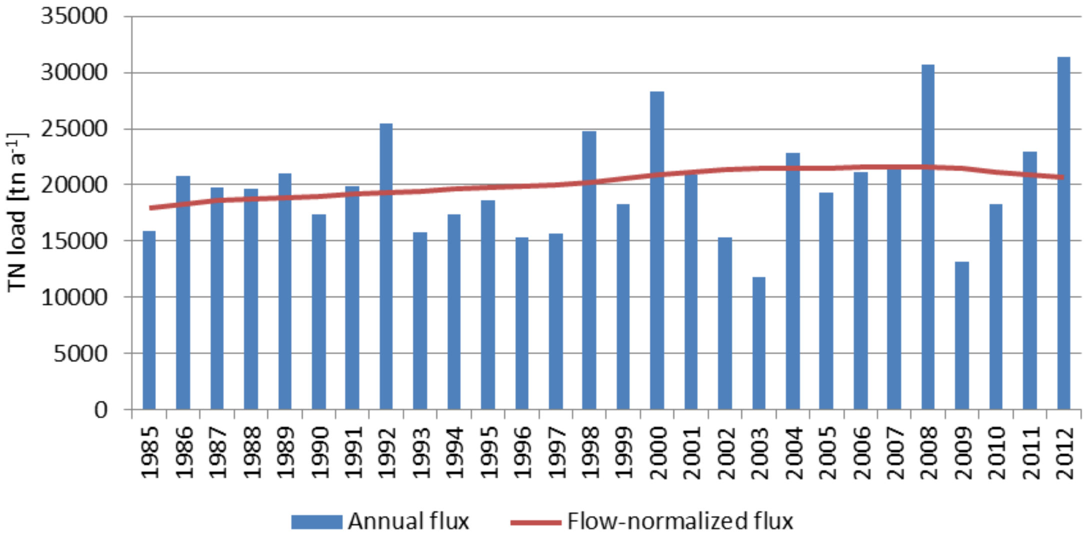
3.4.4 Evidence base and Policy evaluation

Agri-environmental schemes are evaluated and renewed approximately every fifth year. Due difficulties in monitoring non-point source pollution such as nutrient runoff and leaching from agriculture, there is considerable uncertainty regarding the effectiveness of the agri-environmental measures in Finland. The measures with most expected impact on nutrient loads are fertilisation limits and erosion control by various types of tillage and vegetation cover. The effectiveness of both types of these measures has been established in empirical studies, but the overall effects on nutrient concentration in water bodies can be only measured given environmental and production changes unrelated to the measures themselves at a catchment scale, or modeled based on the physical processes.

Agricultural nutrient loading in Finland is evaluated by using long-term monitoring data of discharge and nutrient concentrations of 20 river basins and seven small catchments (Figure 3.4.1). Further, in two of the sub-basins of the large river basins farmers were interviewed annually of their cultivation practices. Altogether these river basins covered 30% of the total field area in Finland. Monitoring of catchments is based on mixed methods including continuous automatic monitoring, periodic water sampling and more detailed less frequent sample analysis.

The largest portion of the agricultural nutrient load (around 80% of the total load) was in the drainage area of the Archipelago Sea. As an average of all river basins, 50% of the total TN load originated from fields if field percentage exceeded 15%. In the case of total phosphorus (TP) the share was even higher.

Specific agricultural TN loading value was 1340 kg km^{-2} yr^{-1} and TP loading value 83 kg km^{-2} yr^{-1}. The TN load from agriculture increased until the period 2000–2006, but then turned to decrease. In Finland large amount of new field has been cleared due to demand of field area in expanding dairy farms since 2000 (Luke, 2013, Niskanen and Lehtonen, 2014). Almost 30% of this new field area was cleared on organic soil types (Niskanen and Lehtonen, 2014), which were naturally rich in N. Clearing of new field explained 50 % of the increase in the TN load to the Baltic Sea between the periods 1995–1999 and 2000–2006 (Rankinen et al., 2016). Increased trend in TN concentrations was partly explained by increased air temperature in early autumn, as higher temperature is assumed to accelerate N mineralization (Aakkula and Leppänen, 2014). Partly, higher concentrations could be explained by cultivation of more N intensive crops (Lankoski and Ollikainen, 2011).



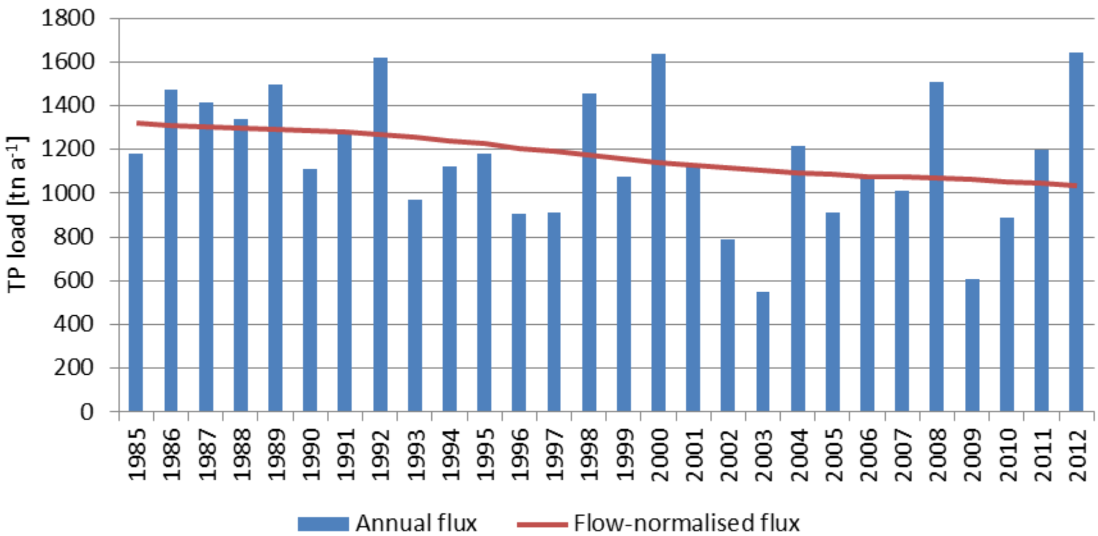


Figure 3.4.1. Annual and flow normalized nutrient fluxes to the Baltic sea from the 20 river basins (Rankinen et al., 2016).

An assessment on N tax in Finland pointed out that fertilisation limits did not reduce the N fertilisation quantities for most crops compared to the average economically optimal levels in any of the Finnish agri-environmental schemes (Hilden et al., 2007). However, in 1990, fertilizer use was 112 kg N ha^{-1} and in 2007–2009, the average N use was 73 kg ha^{-1}(Aakkula and Leppänen, 2014). It seems that pre-EU national yield subsidies had a large impact on the optimal N use.

The TP load peaked already in the first program period (1995-1999) and decreased steadily since then. The decrease was 20% which reached the original target of agri-environmental scheme but was still not enough for achieving the current official targets of the load reduction to the surface waters. As climate or large scale land use changes did not explain the decrease, it can be assumed to be mainly due to success in agri-environmental scheme (Ekholm et al., 2015, Rankinen et al., 2016). For P, the decrease in load can be attributed to both reduced use of fertilisers and increased vegetation cover (period of minimum requirement for fallow, increasing trend in reduced or no-till cultivation, buffer zones and strips) as well as changes in various manure management practices (maximum animal density requirement, limited dispersal periods, trend in hose dispersal). These trends are not only following from agri-environmental or water protection policies, but influenced by non-related increases in input prices, low prices of crops and the general trend of decreasing farm numbers and increasing share of farms managed as secondary source of income.

Studies have shown that for an extensive period before the agri-environmental scheme, farmers were using higher quantities of P than what was removed by crops. This practice was supported by research indicating that the stock of P in the soil would improve the crop yield potential (Saarela, 1997). More recent research has pointed out that lesser soil P stock could be economically optimal for farmers, and in general the current research paradigm advocates less use of P (Ylivainio et al. 2014). Furthermore, increasing fertilisation prices might have made Finnish farmers more conscious of the crop needs. For example in 2008 global P prices peaked with 800% increase (FERTSTAT). Irrespective of the ultimate causes, the average P fertiliser quantities decreased from 30.7 kg P ha^{-1} in 1990 to 7 kg ha^{-1} in 2007-2009 (Aakkula and Leppänen, 2014). For 2008, a drop in global fertilization sale was observed (FERTSTAT). Thus, it seems reasonable to infer that the increasing trend in fertilizer prices in Finland too, has been reflected in applied amounts.

Developments of several agri-environmental measures have shown a positive trend since 1995, and especially nutrient balances and use of commercial fertilizers decreased considerably in Finland in 1990–2006 and that of P only 7 kg ha^{-1} (Aakkula and Leppänen, 2014) for the whole country. The proportion of fallows varied between 6% and 13%. At the same time, the proportion of reduced tillage area increased from 30% to over 80% of the field area. Observed trends in nutrient concentrations or loads are often compared to those in the early 1990's when the share of fallow or set aside land was high. Even though the reason was other than water protection, the effect was positive for water quality.

The link from a lower P balance to a decreased P load is not without problems either. Negative balance will slowly deplete the soil P stock and reduce the load with delay (Ekholm, 2003). High stocks take long to adjust, relative to the periods in Rural Development Programmes.

The control of erosion is a much faster measure to reduce P loads. A reduction in P load could be the outcome of erosion control measures instead of slowly decreasing soil P stock. However, effectiveness of erosion control is not uniform and its performance as a P reduction measure in Finland is debated. There are several studies indicating that while reductions in P ending up to water with eroded particles do happen, simultaneously P is enriched to the surface soil and susceptible to leaching in a more biologically available dissolved form (Muukkonen et al., 2007). The total decrease in the load thus available for algae, and particularly blue-green algae, which can be more harmful to environment, is not reduced as much as would be expected by just analyzing effectiveness of erosion control as a P abatement method.

As expected from different reduction levels of measures even in field experiments, also the watershed and nation level results depend on the sources and tools used to derive them (Puustinen, 2010; Helin and Tattari, 2012). In Finland it seems that the reduction achieved by erosion control measures is overestimated. In watershed models failures to represent the share of dissolved P from the total P load correctly have led to calibrating the particle P share too high. The most recent assessment and monitoring study of the agri-environmental scheme found no statistical significance between increased vegetation cover and the decreased P loads in a river basin scale (Aakkula and Leppänen, 2014). In a sub-basin scale with more detailed data, erosion control methods included in to agri-environmental scheme seemed to work in the erosion sensitive areas but not in the less sensitive areas where increase in dissolved reactive P may exceed the benefits of reduced particulate P load (Rankinen et al., 2016). Therefore focus should be on dissolved nutrients as they cause eutrophication in receiving waters. Thus, the conclusions of limited abatement potential and high abatement costs (Helin, 2013) hold, while the actual potential will be even smaller and costs higher.

There are other measures that could have an effect on nutrient loads. The regulation has been tightening since 1995, e.g. manure spreading on fields in autumn has been gradually decreased though it is still allowed under some circumstances. Among the measures that are so far marginally applied are catch crops, which could have a high potential to reduce N leaching (Valkama et al., 2015). Measures outside the agri-environmental scheme include e.g. gypsum amendment (as well as structural liming) to fields, which has a high potential to reduce both particulate and soluble P losses (Ekholm et al., 2012). Short term solutions should be better targeted to give the best possible benefit. In addition to these short term solutions long-term policy should concentrate on reducing areal hot-spots due to unbalanced production and options to produce environmental benefits as side effects of production.

3.4.5 Targeting and cost-effectiveness

Since there is plenty of variation in the estimated effects of measures on nutrient loads, it is hardly surprising that the cost-effectiveness of measures depends on the underlying assumptions of the estimation methods. What is common between the different estimation methods is that the catchment attributes such as soil types and inclination of fields are not regarded uniform, and thus the loads as well as impacts of the measures depend on the type catchment.

In Finland two approaches have been used to produce cost-effectiveness estimates for both and N and P. VIHMA model developed in Finnish environmental institute (SYKE), generalizes from several Finnish field experiments to estimate the load and impact of different types of measures, while the costs equal the subsidy levels of these measures (Puustinen, 2010). The second approach developed in Natural Resources Institute (Luke) estimates the costs based on least expensive combination of measures given the economic data of Finnish farms, while the effect on N and P is derived from the environmental model used in estimating agricultural load in SYKE (Helin, 2013). As both the costs and effectiveness are derived from different sources, the results regarding cost-effectiviness are not identical (Helin et al., 2010).

Given the first method, separated estimates for each of measures are easy to calculate, but are not guaranteed to reflect the least-cost way of reducing the load. Changing tillage on flat catchments is estimated to cost 980-3500 €/ kg Particle P (PP) 420-660 €/ Kg PP and on catchments with somewhat higher elevation differences, while buffer zones cost 970-1700 €/ Kg and PP 70-140 €/ Kg PP, correspondingly. Less spatial information such as the elevation differences have been taken into account in wetland design and hence the costs are more uniform between the different types of catchments (50-60 €/ Kg PP). In Finland, the national target of abatement from agriculture was set for ca 30%, for which the minimum costs based on the subsidies would be 980 €/ Kg PP for flat and 520 €/ Kg PP for steeper fields. (Helin, 2013, Helin et al., 2010)

In the second method, the underlying interactions between the effects of measures are not based on expert judgement, but on a process model ICECREAM. Since, the cost-efficient combination of measures depends on the type of production, maximum capacity and interactions in efficiency between the individual measures, the effectiveness of the measure varies and the costs per reduced kilo will depend on the level of the abatement target. The cost-efficient solution for reaching the national target (30 %) for total phosphorus (TP) varies between 21 €/ha and 354 €/ha. However, these figures are calculated from the baseline with a higher load per hectare than currently observed, because the current policies and farming trends have increased vegetation cover of fields during winter and thus already reduced the PP loads. Further decreases will be more expensive to reach. Moreover, the required measures can change, and achieving the target level seems to require establishing wetlands on catchments where erosion control measures on fields have already been implemented if reductions are required in short-time. Since wetlands are expensive, a lucrative longer term solution of reducing the total P load would be to reduce P fertilization and consequently the stock of P in the soil.

The variation in the cost-effectiveness of nitrogen measures is smaller between the estimation methods, catchments and measures. The range is from 7 € /kg N to 85 € /kg with first method (25 € /kg for the 30% reduction target and ca 3 € /ha to 84 € /ha for the second method. The low range is achieved mainly by reduced N fertiliser use. Other measures are more expensive, but many of them also lead to lower P-loads, which might not be always the case for reduction in N fertilisation (Helin, 2013; Helin et al., 2010).

In general, the uncertainties related to estimation methods, measures and costs are significant. Using one average number is hardly a reasonable way to describe such results. To improve comparability of the cost-effectiveness estimates, the methods should be documented well, and resources dedicated for establishing frameworks applicable also in cross-country setting should be acquired.

3.4.6 Summary - Finland

Overall objectives have been set for water quality in Finland, but these objectives have not been specific regarding the implementation of water protection measures. For evaluation of the Finnish agri-environmental policy, it is important define against which objectives of the policy are evaluated, since farm income did not cease to be part of the debate concerning the agri-environmental scheme. For policies with multiple objectives, the coherency of all aspects of policy is difficult to achieve.

The most recent scheme has moved further towards environmental and water quality concerns. Compared with previous schemes, the objectives are defined more clearly in terms of specific concern over improving the state of the archipelago sea. However, the connection to actual implementation of WFD objectives is still stated on a general level, instead of well specified connections between measures and specific quality objectives. To some degree this reflects the administrative boundaries between the Ministries of Environment and Agriculture; agri-environmental subsidy scheme is governed in the Ministry of Agriculture and Forestry, while the implementation of the WFS is done under the Ministry of Environment. Partly, the more recent policies might have been designed more cautiously since past objectives have not been reached and the considerably uncertainties regarding the effectiveness of the measures.

The new policy scheme in Finland is based on the revision of CAP. In Finland the “greening” of CAP, is implemented by reducing monoculture cropping, which from the water protection perspective is an ambiguous method. Furthermore, directing subsidies to crops like rye in the new scheme is at odds with the water protection goals, since the subsidies tied to production increase the opportunity costs of water protection measures. Thus, splitting the CAP subsidies between production and environment is not a coherent policy from the water protection perspective. The agri-environmental scheme, as during the previous Rural Development Programmes, is a minor subsidy compared to the financial volume of the whole programme. The general choices in the income element of CAP thus could play larger role in the overall environmental effect of the programme and conflict with the water policy such as the nitrate or water framework directive.

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5 DANISH APPENDIX

Summary of catalogue of measures (Eriksen et al., 2014)

I Tabel A1er samlet en oversigt i meget kort form om de enkelte virkemidler. Desuden er der gengivet nogle af de vigtigste forklaringer og forbehold, som hører med i vurderingen af de enkelte virkemidler. Det er imidlertid nødvendigt at læse den fulde beskrivelse af virkemidlerne for at få et samlet billede af virkning, potentiale, forbehold osv.

TABEL A1

Virkemiddel	Referencepraksis	Årlig N-effekt 1)	Sikkerhed ift. N-effekt	Budget-økonomisk omkostning kr./kg N 2)	Velfærds-økonomisk omkostning kr./kg N 2)
Efterafgrøder	Jord uden efterafgrøde	12-45 kg N ha-1 3)	***	5 - 19 157 - 236 4)	6 - 25 209 - 311 4)
Mellemafgrøder	Vintersæd uden mellemafgrøder	9-13 kg N ha-1	**	30 - 36	39 - 48
Afgrøder med høj N-optagelse: > Sukkerroer > Græs og frøgræs > Foderroer	Jord uden efterafgrøde Jord uden efterafgrøde (Mangler data)	12-45 kg N ha-1 >12-45 kg N ha-1 -	** (samlet bedøm-melse)	-114 – (-156) IV IV	-152 – (-206) IV IV
Tidlig såning af vinter-hvede (7. september)	Normal såning af vinter-hvede (23. september)	5-8 kg N ha-1	**	-80 - 54	-106 - 72
Flerårige energiafgrøder	Kornrige sædskifter under den nuværende regulering	34-51 kg N ha-1 3)	***	-45 - 107	-60-142
Brak (ikke permanent udtagning)	Jord i omdrift	35-58 kg N ha-1 3)	*	28 - 190	37 - 253
Permanent udtagning	Jord i omdrift	50 kg N ha-1	**	69-83	91-130 5)
Randzoner	Jord i omdrift og varig græs	37-74 kg N ha-1	*	47-93	62-123 7)
Fjernelse af biomasse i randzoner og engarealer	Ingen fjernelse af biomasse	Pt. ikke datagrundlag	IV	IV	IV
Skovrejsning	Jord i omdrift	50 kg N ha-1	**	50-153 6)	66-203 6)
Forbud mod jordbear-bejdning i visse perioder	Jord der bearbejdes	10 kg N ha-1	**	1	1-2

Årlige kvælstofeffekter i form af estimeret, reduceret kvælstofudvaskning, sikkerhed i for-hold til estimeret kvælstofeffekt, samt budget- og velfærdsøkonomiske omkostninger for hvert virke-middel. IV og IR angiver, at værdien er henholdsvis ikke vurderet eller ikke relevant.

Virkemiddel	Referencepraksis	Årlig N-effekt 1)	Sikkerhed ift. N-effekt	Budget-økonomisk omkostning kr./kg N 2)	Velfærds-økonomisk omkostning kr./kg N 2)
Forbud mod omlægning af fodergræs om efter-året	Intet forbud mod omlæg-ning om efteråret	36 kg N ha-1	*	14	18
Reduceret jord-bearbejdning	Konventionel jordbear-bejdning	0 8)	**	IV	IV
Nedmuldning af halm før vintersæd	Fjernelse af halm før vintersæd	0 8)	**	IV	IV
Biochar	Ingen biochar produktion og tilsætning	0 8)	IV	IV	IV
Positionsbestemt tilførsel af gødning	Bredspredning af handelsgødning	1-2 kg N ha-1	**	IV	IV
Ændret udbringnings-periode for husdyrgød-ning om efteråret	Husdyrgødningen kan gemmes til næste forår, alternativt udbringes inden 1. september	Samlet effekt: 1850 t N	**	12	15
Afbrænding af husdyrgødning	Antages kun at være aktuelt for biogas-behandlet gylle	Svinegylle: 5 kg N DE-1 Kvæggylle: 8 kg N DE-1 Fjerkrædybstr.: 20 kg N DE-1	**	IV	IV
Kontrolleret dræning	Almindelig dræning	Pt. ikke data-grundlag	*	IV	IV
Konstr. mini-vådområder med over-fladisk afstrømning	Er målrettet dræntrans-port; virker uden for markfladen	5-20 kg N ha-1 opland; 500-3500 kg N ha-1 anlæg	**	21 - 173	27 - 232
Konstr. minivådområ-der med filtermatrice	Er målrettet dræntrans-port; virker uden for markfladen	5-35 kg N ha-1 opland; 500-7000 kg N ha-1 anlæg	**	IV	IV
Vådområder	Jord i omdrift	120-190 kg N ha-1 9)	***	31-33	41-44

Marine virkemidler					
Muslingeopdræ t	IR	600-900 kg N ha-1 10)	**	70-97	93-129 11)
Tangdyrkning	IR	16 kg N ha-1 10)	**	575-805	762-1068 12)
Udplantning af ålegræs	IR	IV	IV	IV	IV
Stenrev	IR	IV	IV	IV	IV

ETTERORD

Takk til Landbruksdirektoratet for økonomisk støtte til prosjektet.

Nøkkelord:	Kostnadseffektivitet, tiltak i landbruket
Key words:	Cost-effectiveness, mitigation measures in agriculture

Norsk institutt for bioøkonomi (NIBIO) ble opprettet 1. juli 2015 som en fusjon av Bioforsk, Norsk institutt for landbruksøkonomisk forskning (NILF) og Norsk institutt for skog og landskap.

Bioøkonomi baserer seg på utnyttelse og forvaltning av biologiske ressurser fra jord og hav, fremfor en fossil økonomi som er basert på kull, olje og gass. NIBIO skal være nasjonalt ledende for utvikling av kunnskap om bioøkonomi.

Gjennom forskning og kunnskapsproduksjon skal instituttet bidra til matsikkerhet, bærekraftig ressursforvaltning, innovasjon og verdiskaping innenfor verdikjedene for mat, skog og andre biobaserte næringer. Instituttet skal levere forskning, forvaltningsstøtte og kunnskap til anvendelse i nasjonal beredskap, forvaltning, næringsliv og samfunnet for øvrig.

NIBIO er eid av Landbruks- og matdepartementet som et forvaltningsorgan med særskilte fullmakter og eget styre. Hovedkontoret er på Ås. Instituttet har flere regionale enheter og et avdelingskontor i Oslo.

Forsidefoto: [Sett inn fotografens navn/eventuell fjernes denne teksten]

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