The increasing impact of environmental policies on agriculture: Perspectives from Norway

Klaus Mittenzwei, Lillian Øygarden

Norwegian Institute of Bioeconomy Research (NIBIO), Norway

*****Email: klaus.mittenzwei@nibio.no

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Klaus Mittenzwei, Lillian Øygarden
Norwegian Institute of Bioeconomy Research (NIBIO), Norway

Abstract
The aim of this paper is twofold. Firstly, it gives an account of recent developments in Norwegian environmental policy that affect agriculture. Climate action and the protection of predators are two prominent examples of environmental policy with a potentially significant impact on agriculture. Secondly, we present results from a partial equilibrium model for the Norwegian agricultural sector in which we use various policy instruments to balance multiple agricultural and environmental objectives regarding agriculture.

1. Introduction

Norwegian agriculture has since the 1980ies had specific environmental objectives within its agricultural policies. However, as will be shown below, these goals have not always been achieved as other goals such as agricultural income, food self-sufficiency, cultural landscape, and agriculture all over the country have dominated environmental objectives. It is only in recent years, and as an effect of the Paris-agreement, that environmental objectives have started to play a more dominating role in the development of agriculture and agricultural policies.

In this study, we analyse whether agricultural and environmental objectives regarding agriculture are complementary or in conflict. We use a partial equilibrium model for the Norwegian agricultural sector to substantiate our analysis. Environmental objectives are frequently not in conflict with each other, while there are conflicts between environmental objectives and non-environmental objectives. The reminder of the paper is as follows. In section 2, we present environmental policies related to agriculture. The model is introduced in section 3, while scenarios and simulations are described in section 4. Results are shown in section 4, while section 5 concludes.

2. Environmental policies related to agriculture

Norwegian agriculture has long faced environmental regulations, but it is only recently that those regulations are considered to have the strength to significantly change agriculture. In this chapter, we present the most important environmental regulations and how they affect the agricultural sector.

2.1 Paris Agreement

The Paris Agreement from 2015 seeks to limit the rise of global temperature well below 2 degrees Celsius compared to pre-industrial levels. Greenhouse gas (GHG) emissions from the agricultural sector, including those reported under the energy sector and LULUCF (land use, land use change and forestry), accounted for 7.1 mill tons CO2-eq. or 13.4 per cent of total emissions in 2016 in Norway (NEA 2018, TA 2018). Norway has committed in the Paris Agreement at least a 40 per cent reduction of all GHG emissions in 2030 compared to 1990. It seeks an implementation of the reduction commitment jointly with the EU. As part of the Effort Sharing Decision (ESD), Norway is ready to accept a goal of reducing GHG emission in the Non-Emission Trading Sectors (NETS) of 40 per cent in 2030 compared to 2005 (Norwegian government 2019a). NETS include transport, heating, agriculture and waste. The Norwegian government has recently increased its national ambition for NETS to 45 per cent and plans to achieve emission cuts domestically (Norwegian government 2019b). Preliminary calculations show that current emission scenarios for NETS until 2030 are not compatible with a 40 per cent cut as envisaged in the ESD. They leave 18.8 mio. t CO2-eq. or 9.2 per cent to be taken by additional measures. Current political ambitions and goals for NETS, mostly within transport, close that gap with 11.6 mio. t CO2-eq. The remainder is calculated to be achieved with measures in transport and agriculture below a marginal abatement cost of about

50 € per t CO2-eq[1] (NEA 2019). The GHG emission reduction potential within this group of measures for agriculture is 4.5 mio. t CO2-eq. This latter amount compares to a 20 per cent reduction of GHG emissions in agriculture between 2005 and 2030. Measures included are reduction of food waste, biogas from manure, a ban of new cultivation of peatland, reduced meat production due to a change towards a more plant- and fish-based diet and various measures to reduce emissions from storage and spreading of manure. Some of these measures are only indirectly covered by the calculation methods in the GHG emission inventory reporting. For example, environmentally-friendly technologies for spreading manure enter the reporting methods only if the use of mineral fertilizer is reduced. The ban of new cultivation of peatland achieves an additional reduction of 0.96 mio. t CO2-eq., but this effect is accounted in the LULUCF-sector. The agreement between Norway and the EU on the ESD allows some flexibility between NETS and LULUCF as well as between NETS and ETS. Should this flexibility be used and if agriculture would be credited for the entire GHG emission cuts from a ban of new cultivation of peatland, the target of 4.5 mio. t CO2-eq. would remain, but could be achieved with fewer measures.

The potential measures listed to achieve GHG emission cuts in agriculture are in different stages of development. The Norwegian Parliament decided lately on a ban of new cultivation of peatland with the possibility of exemption in clearly defined cases. The government has signed a compulsory agreement with major companies in the food value chain to reduce food waste. A subsidy for the use of manure in the production of biogas is established (7 € per t manure). The potential of biogas production from manure has been estimated to 20 per cent of all manure in 2030 (TA 2019), but currently only 1 per cent goes in a biogas reactor. Investment support is available from 2019 for a cover of manure storage facilities as that measure is not economically profitable under current conditions. A similar investment support

[1] 500 Nkr per t CO2-eq. with an exchange rate of 9.67 Nkr per € (30.4.19).

is available for the environmentally-friendly technology of spreading manure. Whether the measure is economically profitable is disputed. Other measures include a better timing, distribution and storage capacity of manure. Their effect is often difficult to quantify as they are not directly represented in the GHG emission accounting methods and measurements. The government currently negotiates with farm organizations an agreement to reduce emissions by 5 mill tons CO2-eq. between 2021 and 2030. The government has announced the implementation of a tax on GHG-emissions from biological production if the negotiations should not succeed.

2.2 EU Water Framework Directive

A gap exists between the target of protecting, and improving if necessary, waterways and the current situation (Øygarden and Bechmann 2017). Measures within the agricultural policy's Regional Environmental Program have improved water quality, but not sufficiently to reach the targets. One quarter of the Norwegian Water bodies are at risk for not fulfilling the requirements of good water quality. Measures for improved water quality in Norway target phosphorus and erosion in Eastern Norway and manure in the Western part of Norway. The Regional Environmental Programme supports measures including subsidies to reduce erosion and phosphorus such as changed tillage operations, cover crops, gras on highly erodible areas, bufferzones, grassed waterways. Support schemes also include drainage and the repair of hydrotechnical equipment. For manure, some counties give support for specific spreading methods, but fewer support schemes are available for this task than for erosion.

The guidelines for manure management are currently under revision with a view of limiting the number of livestock units (LU) per area for manure spreading. The current regulation requires 0.4 ha per LU. Proposals have been made to increase that number to 0.5 ha per LU and 0.7 ha per LU.

2.3 EU Nitrates Directive

Norway has defined the coastal zone in the Inner Oslofjord and the river Glomma as sensitive areas with respect to the Nitrates Directive. The water regions Glomma and Vest-Viken in the South-Eastern area of Norway are the two regions where agriculture accounts for the largest relative contribution of total discharges with 43 and 38 per cent of phosphorous discharges, and 39 and 28 per cent for nitrogen discharges, respectively (Øygarden and Bechmann 2017).

2.4 North Sea Agreement

The North Sea Agreement has a target of a 50 per cent reduction of nitrogen and phosphorus run-offs compared to 1985. The region between the Swedish border and Lindesnes (Norway's southermost point) is considered the most sensitive area with regard to nutrient leaching. Run-offs have decreased somewhat, but a gap still exists between the target and the current situation (Øygarden and Bechmann 2017). The agreement is fulfilled for phosphorus, but not for nitrogen.

2.5 Gothenburg protocol on reduction of air pollution

Norway has a commitment in the Gothenburg protocol to reduce its annual emissions of ammonia (NH3) to a maximum of 23.000 t. Agriculture stands for more than 90 per cent of those emissions. Current emissions are 13 per cent higher than the commitment (Øygarden and Bechmann 2017). A change in the methodology for nitrogen in the Norwegian IPCC accounting system, suggests in increase in run-offs to 45 per cent. The National Environmental Programme aims at reducing ammonia emissions with 8 per cent by 2020. Support for specific spreading methods is given through the Regional Environmental Programme.

2.6 Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)

Bear and wolf have been reinstalled in Norway in the 1980s and 1990s, respectively. The Norwegian Parliament defined so-called “predator zones” in 2004, i.e. zones in which a certain number of predators is protected (Strand 2018). A compensation scheme for sheep killed by wolf or other predators exists. The number of sheep for which payments under the scheme are made, is less than 1 per cent, and probably related due to the retraction of sheep and sheep farming in the predator zones. In these zones, sheep farming management has changed from leaving sheep in mountains and outfields to keeping sheep in fenced infields close to the farm. Around 6 per cent of all sheep is lost due to predators or by other means on an annual basis. Standard econometric analysis of the development of the number of sheep within and without the predator zones between 1999 and 2017 indicates that the predator zones have a positive impact on the number of sheep.

3. Model

Jordmod is a price-endogenous, spatial, comparative-static, and partial equilibrium model for the Norwegian agricultural sector in the tradition of Takayama and Judge (1971). It consists of two modules: a supply module and a market module. The supply module comprises optimization models for farms and for the food industry. The farm optimization models generate input-output coefficients for eleven farm types in thirty-two regions by maximizing farm income. The maximization procedure is subject to fixed input and output prices, Leontief technology for intermediate inputs, non-linear cost functions for labour and capital, and subsidies with partly non-linear payment rates. The responses of cereals and grass yields to nitrogen inputs are modelled as non-linear, as is the relationship between milk yields and feed mix. We examined the use of two types of policy instruments: payments which are (partially) regionally differentiated to compensate for unfavourable natural conditions, and sometimes have successively lower rates to counter economies of scale, and commodity policies such as milk quotas. There are further constraints on agronomic practices (e.g., feed requirements, crop rotation and nutrient needs).

Farms can choose between seven voluntary GHG mitigation options: better quality of fodder, environmentally-friendly spreading of manure, biogass from manure, methane-reducing feed additives for livestock, better timing of tillage, trenching and crop rotation with oilseeds and peas in grain production. These options are costly to farms and not economically profitable in the baseline. Farms may opt to apply mitigation options if a carbon tax is implemented. In this case, the model assumes that emission reductions can be measured and calculated directly for all mitigation options. This is an important simplification as the emission effect of some of the listed mitigation options is difficult to measure and may not even be accounted for the emission accounting system.

Data are taken from the economic accounts (BFJ, div.) and farm account statistics (NILF, div.).

The food industry optimization models minimize total industry costs subject to volume and regional distribution of raw commodities, transport costs between farms and plants, and processing costs at the plants. Models are set up for the dairy industry and the meat industry. Firms process raw commodities into 41 products for final demand. This setup reflects the close connection between primary agriculture and the food industry. It also allows for a detailed representation of trade and trade policies at the processing stage of the food value chain. Except for the cases of dairy products and meat, fixed processing margins are applied for final demand.

The market module consists of 41 final markets. The supply part of the final markets consists of identical farms for each type and region, as well as food industry firms. The number of farms and firms is determined in equilibrium. Final demand enters through linear demand functions that are calibrated to base year levels for each of five market regions aggregated from the production regions. Trade in raw commodities and in final goods occurs between the market regions and the rest of the world at fixed world market prices. Net trade between the world market and the market regions takes place in the presence of trade policies such as import tariffs, import quotas and export subsidies.

Equilibrium in all markets is found by maximizing the sector's aggregate welfare. In principle, the overall solution is found in an iterative process between the supply module and the market module, by which information on output prices and quantities from the market module are used to update the optimization models in the supply module. In the current approach, only one iterative step was required. The model's base year is 2014.

We apply Jordmod, a spatial partial equilibrium model for the Norwegian agricultural sector with a detailed description of agricultural policies and the ability to include policy goals as constraints in the model's objective function (Bullock et al. 2016). The model exercise focused on food production (calories), GHG emissions and agrobiodiversity defined as a mix of land use and livestock intensity. The model has been updated and newly extended with several mitigation options that are currently under discussion (Mittenzwei 2018). We will also include nitrogen run-off and ammonia pollution as specific environmental policy objectives.

4. Simulations

The baseline is constructed as a continuation of current policies (i.e., subsidies, milk quotas and tariffs) and other trends affecting the agricultural sector (i.e., world market prices, population growth, inflation). The model's simulation year is 2030. Values of exogenous variables are projected based on historic trends and available forecasts.

Table x. Assumption for exogenous variables

Variable	Amount	Source
Inflation	2.5 % p.a.	Statistics Norway (2010)
Population growth	1 % p.a.	Statistics Norway (2010)
Real interest rate	1.9 %	OECD and FAO (2011)
Nominal world market prices	1.0 – 5.0 % p.a.	Own assumption
Input saving technical progress	0.5 % p.a.	Own assumption

Four scenarios have been developed to analyse the relationship between environmental policy objectives and agricultural policy objectives. Two scenarios (Env5 and Env7) regard environmental policy objectives only. They differ with respect to the amount of area per LU required for manure spreading. While the limit is set to 0.5 ha per LU in Env5 and AgrEnv5, it is further restricted to 0.7 ha per LU in Env7 and AgrEnv7. A carbon tax is applied in all four scenarios with a carbon price of 23 € per ton CO2-equ. The level is about half the current carbon price in the Norwegian ETS sector and reflects the level of ambition for the agricultural sector.

Table x. Scenario assumptions

Policy measures	Env5	Env7	AgrEnv5	AgrEnv7
Ban on new cultivation of peatland	Available farm land at regional level reduced by 4 percentage points to 10 per cent (national average) compared to base year			
Amount of area per LU required for manure spreading (ha per LU)	0.5	0.7	0.5	0.7
Carbon tax (€ per ton CO2-equ.)	23			
Ammonia emissions	Exogenous limit of N-input to crops			
Food production (energy-based)	Maintain at least levels in the baseline			
Agricultural area	Maintain at least 95 per cent of the utilized agricultural area in the baseline at the regional level			

5. Results

The model simulations indicate that an achievement of environmental policies in agriculture is quite compatible with agricultural policy objectives. This depends, however, on the level of ambition in environmental policies. Higher ambitions are more costly to society and more restrictive to agriculture.

Table x presents the main indicators for environmental and agricultural policy objectives. The reduction in GHG emissions varies between 7.5 and 10 percent compared to the baseline. Emission reductions are positively correlated with the strength of the environmental regulation regarding livestock intensity per area. This is in principle also true for nitrogen surplus, just less pronounced. An increase from .5 to .7 ha per livestock unit contributes only marginally to a larger reduction in nitrogen surplus. The decrease is higher in those regions that are particularly treated by the environmental policies, namely regions in Eastern Norway and along the North Sea cost.

Table x. Main indicators for environmental policy and agricultural policy objectives (percentage change compared to baseline)

	Env5	Env7	AgrEnv5	AgrEnv7
GHG emissions	-8.32	-10.01	-7.56	-7.62
N-surplus	-8.90	-9.17	-8.34	-9.17
of which Eastern Norway	-24.39	-24.39	-24.39	-24.40
of which North Sea coast	-14.13	-14.07	-13.23	-14.07
Ammonia emissions	-8.03	-11.15	-7.15	-8.41
Food production (energy-based)	3.76	3.32	3.79	3.38
Agricultural area	-1.75	-1.54	-1.23	-0.79
Social welfare	-0.73	-0.61	-1.20	-1.18

Source: Own calculations

Food production measured in energy units goes up in all simulations by 3 to 4 per cent compared to the baseline, while agricultural area decreases by 1 to 2 per cent. This indicates that environmental policy objectives do not compromise important agricultural policy objectives. Social welfare decreases by around 1 per cent with a larger reduction when environmental and agricultural policy objectives are achieved simultaneously.

Table x looks into the details of the adjustments following from the implementation of the environmental policy objectives. The percentage reduction in GHG emissions from production, imports and consumption is similar in all simulations. This indicates that the distribution of GHG emissions between production and imports remains about the same. Carbon leakage is therefore not an issue.

The environmental regulation regarding sufficient area for the spreading of manure becomes clearly binding in physical and economic terms. The total amount of nitrogen from manure is reduced by up to 2 per cent compared to the baseline. Mineral fertilizer is even reduced by between 12 and 17 per cent. A stricter requirement of the area for spreading of manure (i.e. switching from .5 ha to .7 ha per LU) implies in fact a smaller decrease in mineral fertilizer. The effect is caused by less manure being available.

The share of the agricultural area for which the manure spreading requirement is binding increases with more than 20 percentage points when the requirement is tightened. The economic value of the requirement becomes about 7 times higher compared to the baseline value.

Table x. Indicators for environmental policy objectives (percentage change compared to baseline)

	Env5	Env7	AgrEnv5	AgrEnv7
GHG-emissions from production	-8.32	-10.01	-7.56	-7.62
GHG-emissions from imports	-9.38	-1.83	-9.34	-4.09
GHG-emissions from consumption	-8.61	-7.80	-8.04	-6.67
Nitrogen from manure	-0.73	-1.82	-0.61	-1.32
Nitrogen from mineral fertilizer	-17.18	-15.13	-15.40	-11.90
Shadow value of manure spreading requirement	-51.39	727.39	-70.68	680.41
Share of manure spreading area affected [1)]	2.08	20.31	0.26	23.82

1) absolute change in percentage points compared to baseline
Source: Own calculations

Similarly, table x shows indicators for agricultural policy objectives. All four simulations reveal a considerable increase in grain production by 20 – 30 per cent compared to the baseline, and a corresponding decrease in meat production by 5 – 7 per cent. Producer prices show only minor changes. Agricultural area is reduced by less than 2 per cent as there is a requirement to maintain 95 per cent of the agricultural area in the baseline at the regional level. Within meat production, the simulations suggest a major reduction of suckler cows that is partially offset by an increase in sheep. The introduction of a carbon tax contributes to a shift from beef production based on suckler cows to grain production as they compete for the same area. When the requirement of manure spreading area is tightened from .5 LU per ha to .7 LU per ha, suckler cows regain profitability compared to sheep production. This development can be observed both with and without agricultural policy objectives in place. Budget support decreases compared to the baseline in the two simulations with environmental policy objectives only, and goes up when agricultural policy objectives have to be achieved as well. Farm income defined as the return to land, labor and capital per man-year in agriculture, shows minor changes compared to the baseline. It goes slightly down in the simulation Env5 and increases in all other simulations. About two-thirds of all farms apply mitigation options. Among available mitigation options, farms with animals implement environmentally-friendly manure spreading technology, while crop farms apply a crop rotation with a higher share of oilseeds and peas.

Table x. Indicators for agricultural policy objectives (percentage change compared to baseline)

	Env5	Env7	AgrEnv5	AgrEnv7
Grain production	29.86	28.18	27.93	22.69
Meat production	-5.12	-7.33	-5.28	-5.87
Producer prices	1.80	3.62	-0.14	0.66
Agricultural area	-1.75	-1.54	-1.23	-0.79
Suckler cows	-60.13	-49.03	-56.31	-38.27
Sheep	20.01	-7.71	20.79	-3.97
Budget support	-3.55	-7.10	3.84	1.38
Farm income per man-year	-1.34	3.29	2.61	5.51
Share of farms with mitigation options [1)]	65.2	61.9	57.6	64.7

1) per cent
Source: Own calculations

6. Discussion and conclusion

Norwegian agriculture has been, and still is, mostly affected by agricultural policy. Food production remains one of the most important objectives for agriculture and is often prioritized above environmental objectives. Measures with agricultural policies have not shown to be able to achieve environmental objectives for agriculture. Recent developments indicate an increasing societal expectation for agriculture to deliver on environmental policy objectives. Our model results indicate that the agricultural sector, by and large, is able to deliver on both agricultural and environmental policy objectives. We expect environmental policies to play a more prominent role – in particular if agricultural policies continue to fall short of achieving policy targets, but also since environmental challenges, such as global warming, may require policy coordination across sectors.

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