The Increasing Impact of Environmental Policies on Agriculture: Perspectives From Norway

Klaus Mittenzwei
Norwegian Institute of Bioeconomy Research (NIBIO)

Lillian Øygarden
Norwegian Institute of Bioeconomy Research (NIBIO)

Environmental concerns such as global warming are expected to require strong political action across the different sectors of the economy. In this paper, we question whether these environmental challenges aggravate the agricultural sector in delivering on agricultural policy objectives. We give an account of recent developments in Norwegian environmental policy that affect agriculture. 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.

Keywords: political economy, agricultural policies, climate change, economic modelling

INTRODUCTION

Following increased emphasis on environmental concerns in the 1980ies, international agreements were put in place to include environmental objectives in e.g. agricultural policies. This development has made agricultural objectives more multifaceted and increased the complexity of potentially conflicting policy objectives. Norwegian agricultural policy objectives have traditionally focused on food production and on maintaining an active agriculture all over the country, in addition to securing a reasonable income to farmers (Ministry of Agriculture and Food, 2011). Most prominently, the Paris-agreement which aims at keeping the global temperature rise well below 2 degrees Celsius compared to pre-industrial levels, is considered a challenge that may threaten agriculture's ability to deliver on agricultural policy objectives.

In this study, we analyse whether specific agricultural and environmental objectives are complementary or in conflict. 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), greenhouse gas (GHG) emissions and agrobiodiversity defined as a mix of land use and livestock intensity. An important drawback of that study was the lack of mitigation options at the farm level which would allow farmers to reduce emissions without reducing production. Consequently, the model has recently been extended with several mitigation options that have been proposed by the farming community to reduce GHG emissions from agriculture (Mittenzwei, 2018). In addition, nitrogen run-off and ammonia pollution has been included in the model as indicators of environmental policy objectives.

The main outcome of the model analysis shows that environmental objectives are frequently not in conflict with each other, while there are latent conflicts between environmental objectives and agricultural objectives that can be potentially overcome by changing the mix in agricultural production from grass-based animal production to crop production.

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.

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.

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 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; Technical Working Group, 2019). Norway's commitment is to reduce all GHG emissions by at least 40 per cent in 2030 compared to 1990. The country seeks an implementation of the reduction commitment jointly with the EU. As part of the RU's Effort Sharing Decision (ESD), Norway accepts a goal of reducing GHG emission in the Non-Emission Trading Sector (Non-ETS) of 40 per cent in 2030 compared to 2005 (Norwegian government, 2019a). Non-ETS include transport, heating, agriculture and waste. The Norwegian government has recently increased its national ambition for Non-ETS to 45 per cent and plans to achieve emission cuts domestically (Norwegian government, 2019b). Preliminary calculations show that current emission scenarios for Non-ETS 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 Non-ETS, mostly within transport, narrow that gap by 11.6 mio. t CO2-eq. The remaining emission cuts must be achieved with measures in transport and agriculture above a marginal abatement cost of about 50 € per t CO2-eq [9.67 Nkr per € as of 30.4.19] (NEA, 2019). The GHG emission reduction potential within this group of measures for agriculture is 4.5 mio. t CO2-eq. This amount compares to 12 per cent of the expected GHG emissions in agriculture between 2021 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 dietary change towards a more plant-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. Banning the new cultivation of peatlands achieves an additional reduction of 0.96 mio. t CO2-eq., but this effect is accounted for in the LULUCF-sector. The agreement between Norway and the EU on the ESD allows some flexibility between Non-ETS and LULUCF as well as between Non-ETS 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. could be achieved with fewer measures.

Several policy instruments, both economic and legal, have been put implemented to achieve GHG emission reductions in agriculture through various mitigation measures. The Norwegian Parliament decided lately to ban the new cultivation of peatland, but allowed for clearly defined exemptions. 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 has been established (7 € per t manure). It has been estimated that up to 20 per cent of all manure is available for biogas production by 2030 (Technical Working Group, 2019). Currently, only 1 per cent of the manure is processed in a biogas reactor. Investment support has been available since 2019 to put a cover on manure storage facilities to avoid nitrous dioxide emission. Similarly, investment support is available for the implementation of environmentally-friendly technologies of spreading manure. Whether that mitigation measure is economically profitable is disputed. Their effect is often difficult to quantify as they are not directly represented in the GHG emission accounting methods and measurements. The government and the farm organizations have agreed on a voluntary agreement to reduce emissions by 5 mill tons CO2-eq. between 2021 and 2030. The government has announced the implementation of a carbon tax on GHG-emissions from biological production if that reduction target will not be achieved.

EU Water Framework Directive

A gap exists between the target of protecting, and improving if necessary, waterways and the current status of those water bodies (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 South-West Norway. The Regional Environmental Programme supports measures including subsidies to reduce erosion and phosphorus such as changed tillage operations, cover crops, grass on highly erodible areas, buffer zones, and grassed waterways. Agri-environmental support schemes also include drainage and the repair of hydrotechnical equipment. For manure, some counties have implemented support schemes for specific spreading methods. A couple of support schemes are available to reduce 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. While the Norwegian Agriculture Agency (NAA) proposes to increase that number to 0.5 ha per LU, the Norwegian Environmental Agency (NEA) suggests additional restrictions setting livestock density to 0.7 ha per LU (NAA and NEA, 2018).

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 South-Eastern 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).

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 southernmost 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.

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.

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 taken by wolf or other predators exists. The number of sheep for which payments under that scheme are made, is less than 1 per cent. 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. In addition, some farmers have quit sheep farming. Around 6 per cent of all sheep are lost due to predators or by other means on an annual basis.

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 about 700 individual farms and for the food industry. The farm optimization models generate input-output coefficients for eleven representative farm types (e.g., cereals, milk, beef, sheep, pork) in thirty-two regions by maximizing farm income under various constraints. 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. Payments are frequently regionally differentiated to compensate for unfavourable natural conditions and have often higher rates for the first units and lower rates for the last units to counter economies of scale. The responses of cereals and grass yields to nitrogen inputs are modelled as non-linear, as is the relationship between milk yields and the feed mix. Agronomic practices such as feed requirements, crop rotation and nutrient needs, are applied as constraints.

The model assumes that all input factors including land, capital and labour achieve a minimum return to reflect opportunity costs. The minimum return of land compares to the income opportunities in the forestry sector, while the interest rate represents the rate of return for own capital. The formula calculating return to labour in the model accounts for the type of production and the farm size. Data from the farm account statistics (NIBIO, various issues) indicate that larger farms achieve a higher return to labour than smaller farms. A reason for that is that smaller farms often have off-farm income and can diversify their household income. This specification implies full mobility of all input factors in agriculture. If input factors do not achieve their minimum return in agriculture, they are expected to leave the sector.

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 for mitigation options if a carbon tax is implemented. In this case, the model assumes that emission reductions can be measured and calculated directly. This is an important simplification as the emission effect of some of the mitigation options is difficult to measure at the farm level. Furthermore, most of the mitigation options in the model can currently not be accounted for in the official GHG emission inventory, because the methodology is too coarse.

The empirical data for the model are taken from many different sources with the economic accounts (Budget committee for agriculture, various issues) and the farm account statistics (NIBIO, various issues) as the most important ones.

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. The 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. Fixed processing margins are applied for the final demand of other products than dairy and meat.

The market module consists of 41 final markets. Supply is represented by an endogenous number of optimized farms from the supply module. The number of farms 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. Milk quotas apply at the level of the production regions and restrict the number of dairy farms in the equilibrium.

Equilibrium in all markets is found by maximizing the sector's aggregate welfare which consists of consumer surplus and producer surplus. Technically, the overall solution is found in an iterative process between the supply module and the market module. Information on output prices and quantities from the market module are used to update the optimization models in the supply module. The model's base year is 2014.

SIMULATIONS

Four scenarios have been developed to analyse the relationship between environmental policy objectives and agricultural policy objectives. The scenarios are compared to a baseline which 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 which means that the agricultural sector is given 16 years to adapt to the policy change which is reasonable since the model implies full mobility of all input factors including capital and labour. Values of exogenous variables are projected based on historic trends and available forecasts such as the OECD/FAO Agricultural Outlook (OECD-FAO, 2011).

TABLE 1
ASSUMPTION FOR EXOGENOUS VARIABLES IN THE SIMULATIONS

Variable	Amount	Source
Inflation	2.5 % p.a.	Statistics Norway (2019)
Population growth	1 % p.a.	Statistics Norway (2019)
Real interest rate	1.9 %	OECD and FAO (2018)
Nominal world market prices	1.0 – 5.0 % p.a.	Own assumption
Input saving technical progress	0.5 % p.a.	Own assumption

Environmental policy objectives are implemented through four different policy measures: a ban on new cultivation of peatland, a restriction of livestock density, a carbon tax and limit on ammonia emissions implemented as a limit of nitrogen input to crops.

The ban on new cultivation of peatland reduces the available agricultural area per region which is reduced by 4-10 percentage points compared to base year levels. Livestock density differs between 0.5 and 0.7 ha per LU to reflect the divergent views of the Agriculture Agency and the Environmental Agency. A carbon tax is applied in all four scenarios with a carbon price of 230 nkr per ton CO_2-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. Nitrogen input to crops is limited to base year values in the two regions that are covered by the EU Nitrate Directive and the North Sea Agreement, respectively.

TABLE 2
SCENARIO ASSUMPTIONS

Policy measure	Env5	Env7	AgrEnv5	AgrEnv7
Ban on new cultivation of peatland	Available regional agricultural area 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 (nkr per ton CO2-equ.)	230	230	230	230
Ammonia emissions	Limitation of N-input to crops			
Food production (calorie-based)			Maintain national baseline food production	
Agriculture all over the country			Maintain min. 95 per cent of baseline regional agricultural area	

In order to assess the relationship between environmental objectives and agricultural objectives, two scenarios (Env5 and Env7) regard environmental objectives only, while two scenarios (AgrEnv5 and AgrEnv7) combine environmental and agricultural objectives. Two policy measures are implemented to achieve agricultural objectives. The first policy measure regards food production and requires maintaining national food production at baseline levels. The second policy measure demands that at least 95 per cent of the agricultural area in the baseline are in active use in each of the 32 regions.

RESULTS

The model simulations indicate that an achievement of environmental objectives by the policy measures in table 2 compatible with the realization of agricultural policy objectives. This general result is qualified, however, by the level of ambition in environmental policies. Higher ambitions are costlier to society and more restrictive to agriculture.

Table 3 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 density. This is 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 the regions in Eastern Norway and along the North Sea cost.

TABLE 3
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 (calorie-based)	3.76	3.32	3.79	3.38
Agricultural area (national level)	-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 increases in all simulations by 3-4 per cent compared to the baseline, while agricultural area decreases by less than 2 per cent. This indicates that environmental policy objectives do not seem to 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. Note, however, that social welfare does not include the value of environmental benefits.

Table 4 investigates the details of the adjustments following from the implementation of the environmental policy objectives. The relative reduction in GHG emissions from production and consumption compared to the baseline is similar in all simulations. However, the decrease in GHG emissions from imports are less pronounced. A change of the livestock density from .5 ha per LU to .7 ha per LU is particularly sensitive to GHG emissions from imports. The lower emission reduction (from -9.38 per cent in Env5 to -1.83 per cent in Env7) hints at a carbon leakage in which domestic production is replaced by imports.

The environmental regulation regarding sufficient area for the spreading of manure (i.e., livestock density) becomes 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 a smaller decrease in mineral fertilizer. The effect is caused by less manure being available from animal production. The share of the agricultural area for which the manure spreading requirement is binding, increases with more than 20 percentage points. The economic value of the requirement, measured as the shadow value of that constraint generated by the model, becomes about 7 times higher compared to the baseline value.

TABLE 4
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

Detailed indicators for agriculture are presented in table 5. 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 due to the 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 carbon tax leads to a shift from beef production based on suckler cows to grain production as both productions compete for the same area. When livestock density is tightened (i.e. switching from Env5/AgrEnv5 to Env7/AgrEnv7), 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 in the two scenarios with environmental policy objectives only and increases in the presence of agricultural policy objectives. 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. 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 5
DETAILED INDICATORS FOR AGRICULTURE
(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

DISCUSSION AND CONCLUSION

Norwegian agriculture has traditionally been governed by agricultural policies. A high degree of self-sufficiency sustained by current food production remains one of the most important objectives for agriculture. The increasing emphasis on environmental concerns since the 1980ies have challenged the dominant position of agricultural policy objectives. The Paris-agreement on GHG emission reductions calls into question agriculture's possibility to deliver on agricultural policy objectives to the same extent as before.

The seemingly conflict between climate mitigation and food production may be not as incompatible as the public discourse may suggest. Our model results indicate that the agricultural sector, by and large, can deliver on both agricultural and environmental policy objectives. This delivery requires, however, a transition in agriculture from grass-based animal production to crop production inducing a shift towards a more plant-based diet.

We expect environmental policies to play a more prominent role – in particular if agricultural policies alone fall short of achieving agricultural and environmental policy targets, but also if environmental challenges, such as global warming, leads to policy coordination across sectors.

The model exercise comes not without caveats as any quantitative model is always a simplified representation of a complex reality. Our model assumes full mobility of all factors of production pointing towards the long-term adjustment of a policy shock. The model abstracts from the current agricultural structure and the path of adjustment. The stronger the policy shock, the larger the potential error of the model to underestimate adjustment costs. That means, in terms of the scenarios, that the policy measures may not be sufficient to achieve the environmental benefits brought about in the model. Moreover, environmental concerns are quite often very local. For example, the EU Water Framework Directive and the EU Nitrate Directive apply to waterways and affect only a specific share of the agricultural area with a region. Our model assumes homogenous agricultural area within at the regional level and is not able to distinguish between area affecting waterways in a particular region. Therefore, limiting nitrogen input to crops in an entire region may overestimate the potential burden to agriculture and the environmental benefits. A profitable venue for future research would be a deeper disaggregation to improve the model's ability to handle local environmental concerns.

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