Governmental policies and measures regulating nitrogen and phosphorus from animal manure in European agriculture[1]

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ABSTRACT: This paper discusses governmental policies and measures that regulate the use of animal manure in the European Union (EU-15). Systematic intervention by governments with European agriculture in general started at the end of the 19th century. Major changes in governmental policies on agriculture followed after the establishment of the EU and its Common Agricultural Policy (CAP) in 1957. Environmental side effects of the large-scale intensification of agricultural production were addressed following the reform of the CAP and the implementation of various environmental regulations and directives from the beginning of the 1990s. The Nitrate Directive approved in 1991 has exerted, as yet, the strongest influence on intensive livestock production systems. This directive regulates the use of N in agriculture, especially through its mandatory measures to designate areas vulnerable to nitrate leaching and to establish action programs and codes of good agricultural practice for these areas. These measures have to ensure that for each farm the amount of N applied via livestock manure shall not exceed 170 kg·ha^{-1}·yr^{-1}. These measures have large consequences, especially for countries with intensive animal agriculture, including The Netherlands, Belgium, Denmark, and Ireland. The mean livestock density in these countries is between 1.5 and 4 livestock units/ha, and the average amounts of N in animal manure range from 100 to 300 kg/ha of agricultural land. More than 10 yr after approval of the Nitrate Directive, there appears to be a delay in the implementation and enforcement in many member states, which reflects in part the major complications that arise from this directive for intensive livestock farming. It also reflects the fact that environmental policies in agriculture have economic consequences. The slow progress in the enforcement of environmental legislations in agriculture combined with the increasing public awareness of food safety, animal welfare, and landscape maintenance call for a more fundamental change in EU agriculture.

Key Words: Environment, Manure, Nitrogen, Phosphorus, Policies

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Introduction

Agriculture exerts various effects on the wider environment. Until recently, these effects were considered to be beneficial, or were simply ignored. This general perception changed from the 1970s onward, when the effects became much larger, following the large-scale intensification of agricultural production and a better understanding through advancements in science. The current perception is that especially intensive agriculture has various negative effects on the environment. Forecasts suggest that further intensification of agricultural production using current technologies may even have dramatic effects on the wider environment during the next decades (Tilman et al., 2001). Especially intensive animal agriculture has been implicated. Main problems arise from excess N and P originating from animal manure and fertilizers, which contribute to eutrophication of natural areas, to contamination of groundwater, and to acidification of soils and lakes.

Governmental policies and measures regulating animal production and the use of animal manure and fertilizers in member states of the European Union (**EU**) date from the second half of the 1980s (e.g., De Clercq et al., 2001). Nowadays, farmers in the EU are confronted with an increasing number of regulations and more administration, which limit the degree of freedom in farming, especially in intensive animal production.

Following brief overviews of the history and the nature of governmental policies and measures, and of some basic characteristics of EU agriculture, this article discusses the policies and measures that affect ani-

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mal agriculture and the use of animal manure and fertilizers in EU agriculture. The Netherlands is used as case study herein to illustrate the effects of such policies and measures on highly intensive animal agriculture.

Historic Overview of Governmental Intervention in Agriculture

Throughout history, the prosperity of societies has greatly depended on the organization of its food supply, or as Braudel (1981) phrases it: "Tell me what you eat, and I will tell you who you are." In ancient societies, most of the working people were involved in food production. People not involved in food production secured their food supply by dictation, barter, and robbery, as in the feudal systems in Europe. Until the Industrial Revolution, food security was organized locally, as there were no large-scale transport facilities, and governmental institutions were absent or weak.

The Enlightenment and the French Revolution, in the eighteen century, marked a major change in the organization of Western societies, when rights of church, king, state, and common people were redefined (Braudel, 1981). Governmental institutions, parliament, and laws became important, and common people obtained basic rights. Soon thereafter, the availability of cheap energy and transport opened up much larger markets, and governmental institutions started to interfere with food production and security. The agricultural crisis of the 1880s provided the stimulus for various governments in Europe for the first time to systematically stimulate agricultural production by subsidizing research, education, and extension, and by subsidizing the reclamation of poor soils. This improved the competitiveness of European farmers relative to that of the immigrants of the New World, who got easy access to fertile prairies. In the early half of the twentieth century, governmental institutions in Europe also started to interfere on food quality, as malversation with butter and other products threatened market positions.

The establishment of the EU with its Common Agricultural Policy (**CAP**) in 1957 marks the second major shift in governmental intervention in agriculture, as responsibilities at national level were transferred to EU level, and intensification of agricultural production was strongly stimulated by price support. The original objectives of the CAP were 1) to increase agricultural productivity, 2) to ensure a fair standard of living for the agricultural community, 3) to stabilize markets, 4) to ensure the stability of supplies, and 5) to ensure that supplies reach the consumers at reasonable prices. This policy has been successful in achieving its objectives, as production strongly increased, facilitated also by cheap fossil energy and modern technology (the Green revolution).

Environmental side effects of the intensification of agricultural production have become apparent since the 1970s. The overproduction of butter, beef, and cereals came at the cost of the environmental sustainability. The surpluses became financial and environmental burdens. This led to a series of reforms of the initial CAP, to stimulate less-intensive production methods with environmental benefits. Milk quotas established in 1984 provided a mechanism for stepwise decreases of dairy cow number. Lower quotas and increased milk yield per cow resulted in 10 to 20% decreases in the number of dairy cows over the last 15 yr. The recognition of large-scale environmental side effects associated with intensive agricultural production marked the third major shift in governmental intervention in agriculture. From the 1980s onward, series of governmental policies and measures were imposed on agriculture so as to limit the environmental side effects of agricultural production.

Policy Instruments for Environmental Strategies

Regulation vs. Stimulation

Environmental policy instruments are based on either regulation or stimulation (Baumol and Oates, 1988). Instruments based on regulation forbid undesired practices and behavior and penalize transgressors (command and control measures, dos and don'ts). Instruments that are based on stimulation reward desired practices and behavior and discourage the undesired. Economic measures (subsidies, premiums, levies, taxes, and tradable permits) stimulate desired practices and discourage undesired practices directly. Education, demonstration, and extension may stimulate desired practices and discourage undesired practices indirectly. These latter, indirect instruments make farmers aware of undesired practices by supplying information, and point at beneficial alternatives. Research is also an important indirect policy instrument because the results may lead to technical change and increased efficiency and hence to higher income and lower N and P losses.

The choice of policy instrument—regulation or stimulation—depends on many factors, including the economic and environmental efficiencies and the legitimacy of the policy instrument. The economic and environmental efficiencies are determined by the trade-off between environmental precision and the transaction costs of implementation and controlling the policy measure in practice. For example, when nitrate leaching on sandy soils is the environmental problem, the policy measure is precise when it restricts leaching losses on sites with groundwater concentrations that are too high in nitrate. However, the costs of enforcing measures only at these sites are high. Alternatively, taxing N fertilizer has low transaction cost, but has low precision, too, because taxing N fertilizer will also affect sites without problems of nitrate in the groundwater. Measures with low precision also raise the issue of legitimacy when they restrict nonpolluting usage. This may be considered unfair or illegitimate (e.g., Romstad et al., 1997).

There is an increasing trend from regulation (command and control measures) toward stimulation and to integrate environmental policies with agricultural policies. Both trends have the potential for bringing greater economic and environmental efficiencies.

Developing Sound Environmental Policies and Measures

A sound environmental strategy in agriculture encompasses four basic elements: 1) the policy instrument (regulation or stimulation), 2) the point of application (where to take action), 3) the addressee (who has to take measures), 4) the spatial dimension of the environmental strategy (which area). As yet, there are very few operational guidelines for the design of environmental polices (Scheele, 1997). Complications arise from the fact that agriculture and environmental conditions (e.g., soils, morphology, and climate) are spatially highly diverse, whereas environmental policy and measures often assume a homogeneity of environmental effects as well as perfect competition among farmers and among sectors. Further, ecological effects associated with excess N and P from agriculture develop gradually, and these problems are not always easily recognized and accepted. For example, visual symptoms of the eutrophication of surface waters by N and P from agriculture emerge slowly. The reverse is also true; decreasing the losses of N and P from agriculture does not quickly revert eutrophic waters to pristine waters. Although the processes of nitrate leaching, ammonia volatilization, eutrophication of surface waters, and acidification of soils were already known at the beginning of the twentieth century, the role and contribution of agricultural practices in these processes were understood only decades later. It took another few decades before proper distinctions between desired and undesired practices were made. By the time of the implementation of policies and measures in the 1980s and 1990s, the undesired activities had become, to some extent, standard practice and thereby were, in part, socially sanctioned. These complicated cause-effect relationships have contributed to the opposition to implementing the policy measures that would regulate N and P in EU agriculture. It also made some policy measures less legitimate (Lowe and Ward, 1997). Evidently, developing sound and legitimate environmental policies and measures in agriculture is a complicated and time-consuming process.

Evaluating Policies via Integrated Environmental Assessment

For the design of policy measures and for the evaluation of their effects, use is made of a conceptual framework, the elements of which are represented by the acronym **DPSIR** (Figure 1). This framework allows an integrated assessment of the cause-effect relationships embodied in the environmental problem and of the effect that policy measures have. Basically, the DPSIR framework provides an iterative process involving the analysis of

1. D = driving forces. What are the driving forces in society, market, technology, and hence in agriculture that lead to changes in agricultural practices and to environmental pressure?
2. P = pressures. Which compounds, for instance, and in what amounts cause the environmental burden?
3. S = states. What are the changes in the environment following the changes in environmental pressure; how do landscape, biodiversity, surface waters, and groundwater change?
4. I = impacts. What are the ecological effects; what are the effects of changes in the state of the environment on the functioning of the biosphere, and its feedback to agriculture and society?
5. R = responses. What is the effect of governmental policy and measures on driving forces, and on environmental pressure, state, and impact? The monitoring of changes in these factors is important because it is the basis for evaluation of the economic and environmental effectiveness of policy and measures.

Agriculture in the European Union

At the time of the EU's foundation in 1957 (at that time, the European Economic Community), there were six member states. Currently, there are 15 member states (**EU-15**) and 10 candidate countries, some of which will join in 2004.

The EU-15 covers 3.2 million km^2 and currently has 380 million inhabitants (Table 1). The utilized agricultural area is 1.29 million km^2, or 40% of the total surface area. The five largest countries—France, Spain, Germany, United Kingdom, and Italy—together possess 79% of all agricultural land in the EU-15. In 1997, there were nearly 7 million farms in the EU-15. Farms in the United Kingdom were the largest (average size of 69 ha), and those in Greece, the smallest (average size of 4.3 ha). Farm structure in the EU-15 differs from that in the United States and in the 10 candidate countries (Table 1). In 1998, 4.7% of the working population found employment in agriculture, ranging from 1.7% in the United Kingdom to 18% in Greece. The mean contribution of primary agriculture to gross domestic production was 1.5%, ranging from 0.8% in Germany to 5.8% in Greece.

Cereals (wheat, barley, corn, and rye) are grown on 28% of the utilized agricultural area. Permanent pasture and green fodder crops, used for animal farming, cover 37 and 3.6% of the area, respectively. The remaining 31% of the utilized agricultural area is used for oil seeds (4.6%), olive trees (3.3%), vineyards (2.6%), sugar beets (1.6%), potatoes (1%), and various other small crops. Switzerland (71%), Ireland (69%), United Kingdom (64%), and The Netherlands (64%) have the

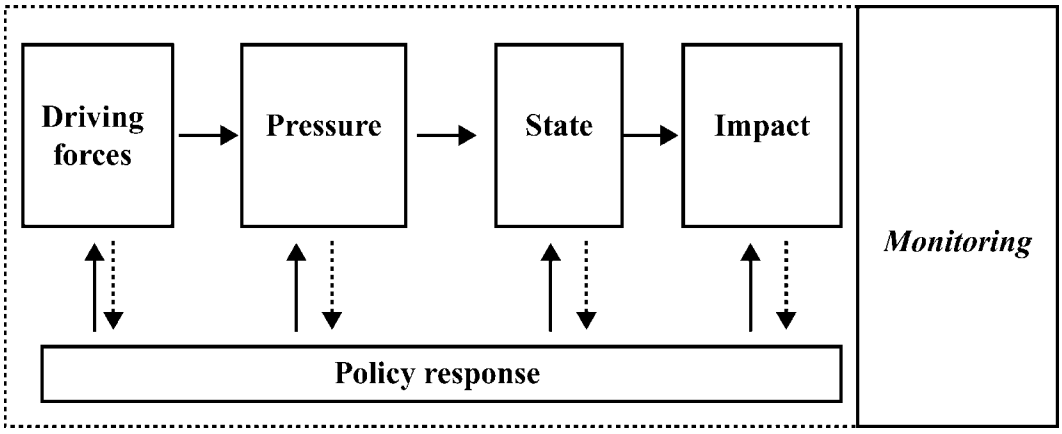

Figure 1. The framework DPSIR for integrated assessment of the effects of the response of policy and measures on the driving forces of environmental pressure and on its changes in the state of the environment and its ecological impact. Sometimes, this framework is simplified to Driving force—State—Response.

largest relative areas of pasture and fodder crops used for (grazing) animals. Sweden and Finland have the largest forest areas.

The total number of cattle is 83 million, of which 21 million are dairy cows. The EU-15 ranks fifth in the number of cattle in the world, after India (about 220 million), Brazil (175 million), China (110 million), and the United States (90 million). The average number of dairy cows per farm in 1999 was 24, ranging from a mean of 5 in Portugal to 44 in The Netherlands, 51 in Denmark, and 69 in the United Kingdom.

The total number of pigs is 125 million. The EU-15 rank first in number of pigs in the world, followed by China (80 million) and the United States (59 million). The largest pig producers among the EU-15 are Germany, Spain, The Netherlands, France, and Denmark. The average number of pigs per farm is 106, ranging from 18 in Portugal to 605 in Denmark, 723 in The Netherlands, and 859 in Ireland.

The average amounts of N applied to agricultural land in 1997 via animal manure and fertilizers ranged, respectively, from 47 and 37 kg/ha in Austria to 100 and 124 kg/ha in Denmark and to 307 and 186 kg/ha in The Netherlands. Similarly, the average amounts of P applied to agricultural land in 1997 via animal manure and fertilizers ranged, respectively, from 24 and 7 kg/ha in Austria to 43 and 8 kg/ha in Denmark and to 104 and 13 kg/ha in The Netherlands. Fertilizer input of N and especially P has decreased during the 1990s.

The average N surplus in the EU-15 was 57 kg/ha in 1997, ranging from 30 kg/ha in Greece to 112 kg/ha in Denmark and 249 kg/ha in The Netherlands. There is strong correlation among livestock density, N fertilizer input, and N surplus per hectare: countries with the highest livestock density also have the highest N fertilizer input and highest N surplus on the soil surface balance (Figure 2). Correlation coefficients for linear relationships between fertilizer N, manure N, and N surplus in the EU-15 range between 0.8 and 0.9.

Policy and Measures in EU Agriculture

Agricultural Policy in the Pre-Environmental Era

The CAP has had significant impacts on agriculture and the countryside. The CAP has been in place during what has been described as "the most widespread and rapid transformation of the rural environment in the whole of European history, though it is naïve to ascribe all changes to the CAP alone" (Brouwer and Lowe, 1998). The CAP has given a strong impetus to intensification and rationalization of agricultural production.

The incentives provided by the CAP were not without economic costs; the expenditures for supporting CAP have risen steadily from about €12 billion (euros) in 1980 to €25 billion in 1990 and to more than €40 billion in 2000. This support is about 40% of the total expenditures of the European Commission but is less than 2% of the total governmental expenditures of the EU-15 and less than 1.27% (maximum level) of gross domestic production. For the next 6 yr (2003 to 2008), expenditures to support CAP have been fixed at a maximum of €43 billion. Figure 3 shows the changes in the expenditures. Following the reform of the CAP in 1992, there has been a shift from price support to income support. Following the next reform according to Agenda 2000 and more recent reforms (Mid-Term Review in June 2003), there will be further shifts from price support to income support and a further shift from supporting agricultural production to the maintenance of rural areas (European Commission, 2003). The support for animal agriculture (meat and milk) ranged between €5 and 10 billion during the last 20 yr; currently, it is about 25% of the total expenditures for the CAP.

Environmental side effects of the intensification of the agricultural production were not addressed initially, partly because of a lack of recognition and partly because the European Commission did not have the necessary legal means to deal effectively with environ-

Table 1. Basic agricultural data of member states of the European Union (EU-15). At the bottom, selective basic information of candidate countries (CC-10) and of the United States have been included

Country[a]	Population, millions	Employment in agric., %	Agricultural area		Cereals, %	Grassland, %	Livestock number, million			Livestock number	
			% of total	Megahectares			Cattle	Dairy	Pigs	hectares	holding
Austria	8	7	41	3	25	53	2.1	0.7	3.4	0.82	19
Belgium + L*	11	2	46	2	22	47	3.1	0.6	7.7	3.14	84
Denmark	5	4	63	3	56	14	1.9	0.6	11.6	1.59	96
Finland	5	7	7	2	52	5	1.1	0.4	1.5	0.59	26
France	59	4	52	28	30	35	20.2	4.4	15.9	0.88	48
Germany	82	3	48	17	41	30	14.9	4.8	26.1	1.10	48
Greece	11	18	27	4	37	57	0.6	0.2	1	0.66	5
Ireland	4	11	61	4	7	69	6.6	1.2	1.8	1.60	48
Italy	58	6	49	15	24	28	7.2	2.1	8.4	0.72	15
Netherlands	16	4	56	2	11	53	4.2	1.7	14	3.85	104
Portugal	10	14	41	4	17	26	1.4	0.4	2.4	0.61	7
Spain	40	8	51	26	23	35	6.3	1.2	22.4	0.44	27
Sweden	9	3	7	3	41	15	1.7	0.4	2.1	0.68	37
United Kingdom	60	2	66	16	22	64	11.2	2.5	7	1.02	94
EU-15	378	5	40	128	28	37	82.7	21.1	125	0.90	33
CC-10	75	13	51	38							
United States	285	2	40	381							

[a]Begium + L* = Belgium and Luxembourg.

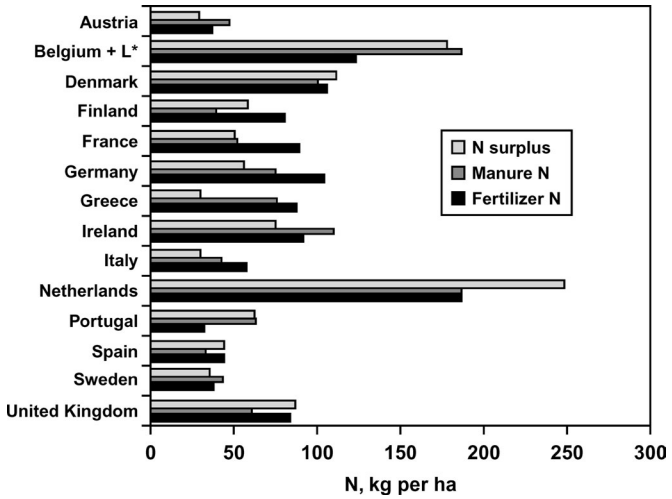

Figure 2. Total N input on agricultural land via fertilizers and animal manure, and total mean N surplus in the 15 EU member states in 1997. Belgium + L* = Belgium and Luxembourg (OECD, 2001; DG-AGRI, 2002; Eurostat, 2003).

mental problems in the EU-15 until 1986 (De Clercq et al., 2001).

The Role of International Agreements

International treaties have given a strong impetus to the public awareness and recognition of the effects of eutrophication by N and P on the ecology of surface waters. These treaties have also given a strong impetus to the implementation of national environmental policies and to harmonize environmental objectives and standards among EU countries (De Walle and Sevenster, 1998; De Clercq et al., 2001). These multinational environmental agreements date from the second half of the 1980s and the first half of 1990s. Important treaties include the Oslo and Paris Conventions aimed at preventing marine pollution in general, the Helsinki Commission aimed at protecting the Baltic Sea, the North Sea Conferences aimed at protecting the North Sea, and the Mediterranean Action Plan aimed at protecting the Mediterranean Sea. In 1995, the Oslo and Paris Conventions introduced N and P balances for evaluating the progress at national level to decrease N and P surpluses by 50% each, relative to the year 1985, and by doing so to decrease N and P discharges in the environment by agriculture, industry, and households. All of these agreements have had a strong impact on the development and implementation of environmental policies and measures in individual EU countries.

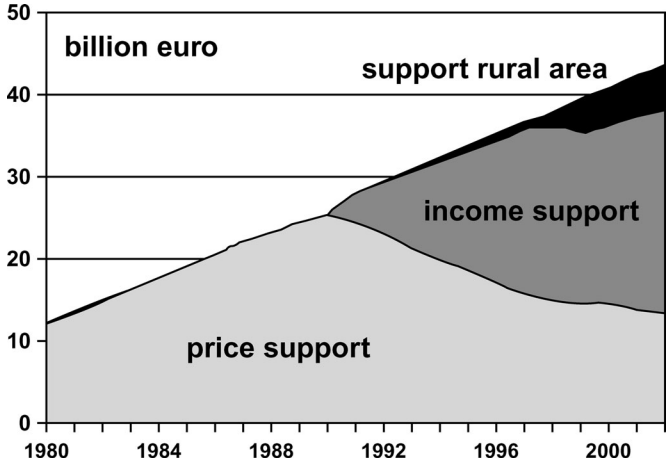

Figure 3. Changes in the expenditures to support the Common Agricultural Policy in the 15 EU member states in the period 1980 to 2002 (DG-AGRI, 2002).

Environmental Policies and Measures

From the early 1990s onward, EU environmental policies and measures have increasingly affected agricultural production and started to overrule national environmental policies and measures. Currently, there are two types of environmental legislation in the EU, namely, regulations and directives. Regulations are binding and directly applicable in all member states. Regulations must be complied with fully by those addressed (individuals, member states, institutions). Directives are also binding, but the objectives of the directives can be achieved in different ways by member states (choice of the form and methods to apply). With the reform of the CAP, there is a clear trend of integrating environmental targets into agricultural policy.

Currently, agriculture and especially the use of animal manure and fertilizers are affected by three categories of EU policies and measures (e.g., De Clerck et al., 2001): 1) Agenda 2000 and the reform of CAP, 2) the Water Framework Directive, and 3) the Air Quality Directive. These are discussed below.

Agenda 2000

Agenda 2000 is an action program launched in 1999 by the EU to increase competitiveness, to enhance standards of food safety and quality, and to ensure a fair standard of living for the agricultural community. It addresses the reform of the CAP and the structural policy, including the uncoupling of production and income support. Within Agenda 2000, there are two regulations that affect N and P use. Regulation 1259/99 establishes common rules for direct payments to farmers in return for agri-environmental commitments. Regulation 1257/99 supports sustainable rural development to restore and enhance competitiveness. The focus of Agenda 2000 is on 1) less-favored areas and areas with environmental restrictions and 2) on agricultural production methods designed to protect the environment and to maintain the countryside. Hence, farmers who apply good farming practices, decrease livestock density, maintain the landscape, and/or conserve areas with high nature value can be granted a compensatory allowance.

The Water Framework Directive

The Water Framework Directive is the most substantial piece of EU water legislation. It requires all inland and coastal waters to reach good ecological status by 2015. It will do this by establishing a river basin district structure within which demanding environmental objectives will be set, including ecological targets for surface waters. It addresses all compounds that affect the ecological status of surface waters, including N and P from agriculture. The Water Framework Directive establishes also a framework for the Integrated Program on Water Quality Management. It includes 1) water quality standards, 2) emission limits, and 3) legislation and measures. It encompasses a large number of other directives. So far, most important for agriculture is the Nitrate Directive (91/676/EC), which was agreed upon by all member states in 1991 and which must have been implemented by 2003. In the next decade, the demanding environmental objectives for P in surface waters in the Water Framework Directive itself will have an even greater impact on agriculture than the Nitrate Directive currently has.

The main objective of the Nitrate Directive is "to decrease water pollution caused or induced by nitrates from agricultural sources and prevent further such pollution." For this, all member states have to take various measures (i.e., designate vulnerable zones and establish action and monitoring programs and a code of good agricultural practices for these zones). Nitrate-vulnerable zones must be designated on the basis of monitoring results, which indicate that the groundwater and surface waters in these zones are or could be affected by nitrate pollution from agriculture. So far, Austria, Denmark, Finland, Germany, Luxembourg, and The Netherlands have designated the whole territory as a nitrate-vulnerable zone, whereas other member states have designated only a part of the country as nitrate-vulnerable zone. The difference in designation between member states is only partly related to the actual pollution with nitrate. Some member states designated the whole territory to keep measures uniform, to avoid unfair competition among various groups of farmers, and to raise environmental awareness among all farmers (De Clercq et al., 2001).

The action program must contain mandatory measures relating to 1) periods when application of animal manure and fertilizers is prohibited, 2) capacity of and facilities for the storage of animal manure, and 3) limits to the amounts of animal manure and fertilizers applied to land. These measures must ensure that for each farm in vulnerable areas the amount of N applied via animal manure, including that deposited by grazing animals, shall not exceed 170 $kg \cdot ha^{-1} \cdot yr^{-1}$. Member states are obliged to monitor the nitrate concentrations of groundwater and surface waters, to assess the impact of the measures, and to report the results to the European Commission. So far, there is a wide variation between member states in the interpretation and implementation of action programs and codes of good agricultural practices (De Clercq et al., 2001).

The limit of 170 $kg \cdot ha^{-1} \cdot yr^{-1}$ of N from animal manure on a per-farm basis has been questioned because it strongly limits livestock density per farm, and there is no scientific justification for one uniform limit for all agricultural land. A note in the annex of the Nitrate Directive may provide a way out: member states may derogate from this limit and may apply more N via animal manure when justified on the basis of scientifically and practically sound data and arguments. A few countries applied for derogation (Denmark, Germany, and The Netherlands). Points of discussion are the height (250, 230, 210 $kg \cdot ha^{-1} \cdot yr^{-1}$ of N) and the criteria (e.g., surface area, land use, drainage, duration) for derogation.

The EU Air Quality Directive

The EU Air Quality Directive (1999/30/EC) sets limits on the emission of ammonia and nitrogen oxides (and other gases, mainly from industrial sources and traffic) into the atmosphere, so as to abate acidification, eutrophication, and ground-level ozone. The directive sets targets for emission reduction to be reached in 2010 relative to the reference year 1990. The emission reduction targets for ammonia range between 0 and 43% for individual member states. Mitigation measures for agriculture focus on the use of urea and ammonium-based fertilizers, manure application, manure storage, animal housing, and an advisory code of good agricultural practice. The strict emission reduction targets necessitate livestock farmers in some member states to use low-protein animal feed and low-emission techniques for the storage, handling, and application of animal manures.

Effects of Policies on Animal Agriculture in The Netherlands

Effects of environmental policies and measures on agriculture in the EU and especially on animal agriculture have been largest in The Netherlands. Agriculture in The Netherlands is highly intensive. Although one of the smaller member states (Table 1), The Netherlands is the largest net exporter of agricultural products in the world, when expressed in monetary terms (Silvis and Van Bruchem, 2002), mainly through the export of animal products and flowers. Current average livestock density is slightly less than 4 livestock units per hectare (Table 1). The large-scale intensification of animal production took place mainly between 1950 and 1985.

The first signals that the rapid intensification of animal agriculture was not environmentally sustainable date from the end of the 1960s. Animal agriculture in The Netherlands heavily relies on imported animal feed, and, although a large fraction of the animal products is exported, the animal manure containing most of the nutrients of the animal feed and feed additives

is applied to the small acreage of the animal producers. A manure surplus was created, which contributed to a net accumulation of P and heavy metals in soil and to high emissions of ammonia to the atmosphere, of nitrate to groundwater, and of N and P to surface waters. Initial worries were centered on the toxic effects associated with the accumulation of Cu and Zn in soil, forest dieback and lake acidification associated with high emissions of ammonia to the atmosphere, and surface water eutrophication associated with P leaching from P-saturated soils. The approval of the EU Nitrates Directive in 1991 shifted the focus in the 1990s to nitrate in groundwater.

The first governmental policies and measures regulating animal manure date from 1984. There are three phases in the manure policy followed in The Netherlands (Henkens and Van Keulen, 2001), namely 1) stop increasing animal production (1984 to 1990), 2) stepwise decrease of the manure burden (1990 to 1998), and 3) move toward balanced inputs of N and P (1998 to present). During the first phase, quotas for manure production per farm and limits for manure application to land based on P were implemented, and techniques for low-emission storage, handling, and application of animal manure were introduced. During the second phase, limits for manure production based on P were lowered stepwise, and a subsidized infrastructure was set up for transporting manure from areas with manure surplus to areas without surplus (a surplus is defined here relative to the application limits). In the third phase, the Mineral Accounting System (**MINAS**) and manure application limits based on N were implemented in response to the EU Nitrates Directive. Basically, MINAS is a farm-gate balance that records all inputs and outputs of N and P at farm level. The MINAS system includes levy-free surpluses that account for the surplus input over output of N and P, which are not charged by a levy. The levy-free surpluses include the unaccounted-for N and P and the environmentally acceptable losses of N and P, and are differentiated by land use and soil type. Surpluses at the farm level that exceed levy-free surpluses are charged (2.30 euro·kg^{-1}·ha^{-1} for N and 20.60 euro·kg^{-1}·ha^{-1} for P). Levy-free surpluses have decreased stepwise between 1998 and 2003, on the basis of political compromises between what is environmentally acceptable and agronomically feasible. Levy-free surpluses for 2003 were in the range of 100 to 180 kg·ha^{-1}·yr^{-1} for N and 8.7 kg·ha^{-1}·yr^{-1} for P. During the next years, they may decrease further to 40 to 100 kg·ha^{-1}·yr^{-1} for N and to 0.4 kg·ha^{-1}·yr^{-1} for P (RIVM, 2002).

The manure policy provides strong incentives to use N and P at the farm level more efficiently (e.g., Van Bruchem et al., 1999; RIVM, 2002). As a result, mean surpluses of N and P of dairy farms, for example, have decreased by more than 50% within a period of 15 yr. Pilot farmers were able to lower the surpluses of N and P by more than 50% within 2 yr. However, the economic costs and administrative burden of the manure policy

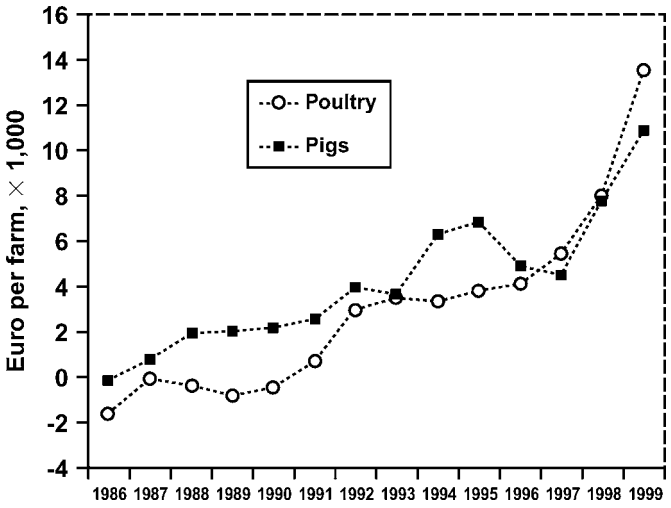

Figure 4. Changes in the cost of manure disposal per farm for specialized poultry and pig producers in the period 1986 to 1999 (after RIVM, 2002).

are high, especially for specialized livestock farmers and for the government. In 1998 to 2000, dairy farms paid on average €1,000 to €2,000 and pig and poultry farms on average €4,000 to €5,000 per farm on levies because surpluses of N and P exceeded levy-free surpluses at the farm level (RIVM, 2002). The costs of manure disposal rose especially after the implementation of MINAS in 1998 and following the stepwise decrease of levy-free surpluses (Figure 4). The cost of manure disposal for specialized livestock farmers was in the range of €5 to €20 per megagram; approximately €5 to €10 was for transport, and the remainder for arable farmers accepting the manure. The price of the manure is regulated by the manure market (Figure 5); the balance between supply and demand defines the price (Hoogeveen and Leneman, 2001). The government intervenes with the manure market by changing the limits for manure application, buying out animal quota, and by facilitating manure transport and processing, and through research and extension services. In 2001 to 2002, the government bought up the animal quota from farmers who terminated farming and thereby decreased the number of pigs by about 10% at the cost of about €0.5 billion (Van Staalduinen et al., 2002). This intervention has relieved the pressure on the manure market, but most of the relief has to come from efficiency gains by animal livestock farmers, by improved management and lowered N and P contents in animal feed.

Although the results of monitoring programs indicate that MINAS is effective in decreasing N and P surpluses and in improving the N and P use efficiency at the farm level (e.g., RIVM, 2002), the European Commission has not accepted MINAS as a suitable instrument for achieving the objectives of the EU Nitrate Directive. By the end of the 1999, the European Commission brought The Netherlands government to the European Court, which subsequently condemned the manure pol-

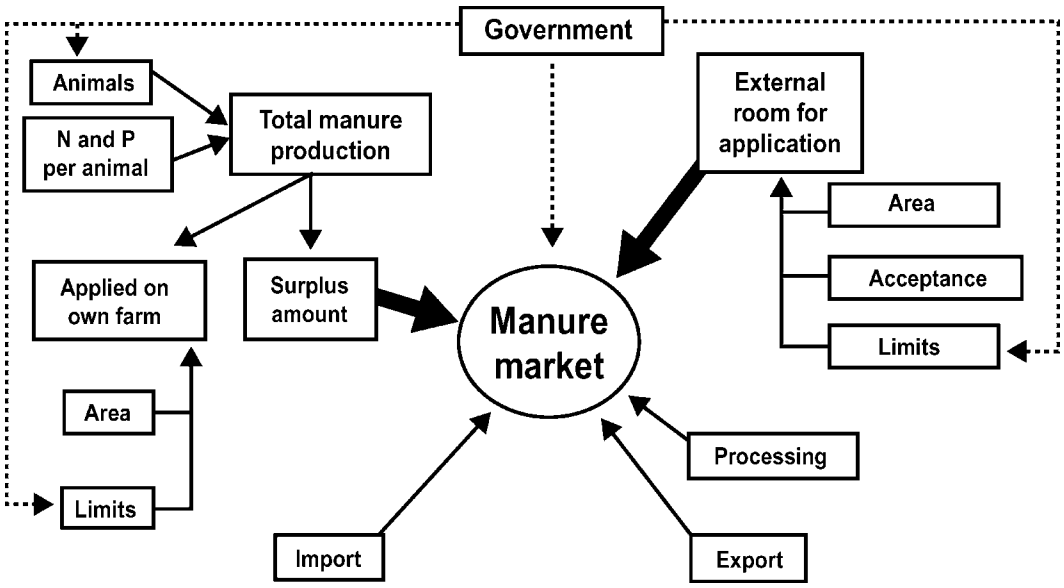

Figure 5. The manure market, with the supply side on the left-hand side and the demand side on the right-hand side. The government may intervene (indicated by dashed lines) in the manure market via changing limits of animal manure; buying out animal quota; and by facilitating research, extension services, and manure transport through subsidies (after Hoogeveen and Leneman, 2001).

icy of the Netherlands in its arrest released on October 2, 2003. Main arguments given by the European Court were 1) the MINAS system does not comply with the regulatory system prescribed by the Nitrate Directives, 2) the application limits for animal manure and the levy-free surpluses set for the years preceding 2000 were too high, and 3) essential regulations of the manure policy were implemented too late. Except from paying a €0.25-billion fine, The Netherlands must soon implement new regulations for N (and P) compatible with the Nitrate Directive.

Discussion

An awareness of the side effects of intensive agricultural production marks a major change in the relationship between agriculture and society. Traditionally, agriculture was a major source of natural values and a key mediator of natural morality. The imposition of regulatory controls has in part stigmatized farmers as environmental criminals, especially in countries with high livestock density. Environmental pollution by agriculture has become a politicized problem (Lowe and Ward, 1997).

Governmental intervention in agriculture has a history of more than 100 yr, but environmental regulations in agriculture cover a period of less than 20 yr. The governmental policy and measures regulating N and P in agriculture in EU member states are still diverse, despite the harmonization by the EU. This is in part due to the subsidiarity principle, leading to considerable variation in national and regional responses to directives. Subsidiarity in part also reflects the varied nature of the European rural environment and of the social values attached to them. There are also large differences among member states in the use of various agri-environmental measures. For example, the share of the agricultural area under low-intensity farming ranges from (less than) 10% for countries like The Netherlands and United Kingdom to 60% for Portugal and Greece and 80% for Spain (Brouwer and Lowe, 1998).

The 1992 CAP reform strongly decreased the price of cereals in the EU. Arable farmers were forced to lower the cost of production and were compensated in part by direct payments. As a side effect of the lowered prices, cereals produced in the EU became attractive for livestock farmers to be used as animal feed. The proportion of EU cereals in animal feed increased at the expense of imported soybean. This in turn lowered the price and the protein content of the animal feed. Hence, the reform of the arable crop regime significantly decreased the cost and the protein content of animal feed and thereby also alleviated the environmental burden in areas with intensive livestock farming. This example illustrates the complicated relationships amid policy and measures, market developments, and environmental effects. It also illustrates that policy and measures may have effects across sectors (Brouwer and Lowe, 1998).

The implementation of environmental measures implies in part that the environmental costs of agricultural production are internalized in the decision making and economic costs of farming. Farmers will have to change farming practices and may have to invest in, for example, manure storage facilities, manure applicators, and manure disposal. Some of these changes are

economically beneficial, especially for arable farmers and many dairy farmers, but not for specialized livestock farmers (RIVM, 2002). Low-emission techniques increased the costs for manure application by €2 to €5/t of animal manure. The annual cost of manure disposal for intensive livestock farms in The Netherlands had increased to more than €10,000 per farm (Figure 4). The annual costs associated with the administration of the MINAS farm-gate balance are estimated at €1,500 per farm. In addition, many farmers paid high levies for N and P surpluses that exceed levy-free surpluses. All of these costs impair the profitability of farming. On the other hand, these economic costs provide the incentive for improving farming practices and for increasing the efficiency of N and P use at the farm level (RIVM, 2002). However, farmers need time to adopt new techniques and management styles to adjust to improved farming practices. They have to learn and they have to be convinced of the need for change; otherwise, they remain reluctant to change and ignorant of improved practices. There are also economic costs for governments, associated with the enforcement and control of the environmental measures. For example, the MINAS balance sheets of all farms have to be verified. In 2002, on average one civil servant was needed to verify and sometimes to complete the MINAS balance sheets of 150 farms. Evidently, the high costs associated with the implementation of environmental policies and measures indicate that the economic efficiency of these policies and measures in agriculture is still low.

Differences among member states in the compliance with EU policy and measures can be large, as may follow from a comparison of for example, Denmark and The Netherlands. Denmark has an intensive livestock production sector, though not as large as The Netherlands (Figure 2). Denmark also designated the whole territory as vulnerable to nitrate leaching. However, Denmark has fewer problems with implementation of the EU Nitrate Directive than The Netherlands. Differences in agricultural structure and in environmental policies and measures may explain the differences in compliance with the Nitrate Directive. First, animal production in Denmark is evenly distributed over the country, but in The Netherlands it is highly concentrated in the south and east. Second, feed for pig production in Denmark is grown in the country, whereas feed for pig production in The Netherlands is imported. Third, intensification of livestock production in The Netherlands started earlier, before any environmental policies, whereas the opposite is more or less true for Denmark. Fourth, Denmark is surrounded by sea for more than 90% of its boundaries, whereas The Netherlands, for only about 40%. As a result, there is more across-border interaction of animal feed, animal manure, and fertilizers in The Netherlands than in Denmark, and these interactions affect the monitoring of the efficacy of environmental policies and measures. Fifth, Denmark implemented an N and P regulatory system in agriculture that complies with the Nitrate Directives, whereas the MINAS system of The Netherlands does not comply with the EU Nitrate Directive.

Due to the increased awareness of the environmental effects resulting from large-scale intensification of agricultural production, the emphasis of governmental policies shifted from food security and food quality to environmentally sound food production. The emphasis on food safety and animal welfare in more recent EU governmental policies (CAP reform) emerged especially in response to the recent BSE and foot and mouth disease epidemics in Europe. The slow progress in the enforcement of environmental legislation in agriculture—combined with the recent increased public awareness of food safety, animal welfare, and landscape maintenance—warrant a more fundamental change in EU agriculture (e.g., Vereijken 2002).

Implications

Agriculture in Europe is increasingly affected by policies and measures. The effectiveness of these environmental policy and measures is still limited, whereas the economic cost associated with their implementation is often high. Differences in national and regional responses to the European Union policies and measures, partly due to delays in implementation and enforcement, may affect the perceived competitiveness of farmers among member states, which is then used as an argument for further delaying the implementation of environmental policies and measures. Such delays and the low environmental effectiveness and low economic efficiency limit the confidence in current environmental policies as instruments to achieve sustainable agriculture. Clearly, dealing with environmental policies and measures in agriculture is still a fairly new policy field with many imperfections. The modest effectiveness of current environmental policies combined with the recent increased public awareness of food safety, animal welfare, biodiversity, and landscape maintenance warrant a more fundamental change in EU agriculture.

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