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THE IMPACT OF ENVIRONMENTAL POLICY ON NITROGEN BALANCES AT FARM LEVEL IN THE EUROPEAN UNION

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ABSTRACT

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The impact of environmental policy instruments for the control of nitrate pollution from agricultural sources on income and nitrogen balances is assessed at farm level in the European Union. A Linear-Programming model at farm level has been used. Individual farm optimizations are based on the 1990/91 sample of the Farm Accountancy Data Network (FADN) of the European Commission. Variable costs are obtained from the Sectoral Production and Income model for agriculture (SPEL). A standard on the application of nitrogen from organic manure and a levy on the nitrogen surplus are assessed. CAP Reform is considered in the analysis. Three farming types are distinguished; dairy, granivore and cereal farms.

The way farms are affected by policy instruments varies largely across groups of farms in the European Union because of the differences in farm structure, input use and the way organic manure is treated at the farm. Adjustment possibilities as a result of policy changes are mainly limited to flows of organic manure in the assessments made.

The supply of animal manure in EUR 12 exceeds 170 kg of nitrogen per hectare (excluding emission losses) on approximately 19% of the number of dairy holdings and 87% of the number of granivore holdings represented by FADN. This is the equivalent of almost 115 thousand dairy and 53 thousand granivore holdings. The increasing pressure on the manure market in response to the policy scenarios assessed is mainly the result of the increase in the amount of manure disposed at dairy farms and to a lesser extent at granivore farms. Granivore farms were already affected by existing environmental policy.

Several adjustments in farming practice are to be expected to meet the requirements of policy. The impact of a more efficient use of feed concentrates, the replacement of inorganic fertilizers by organic manure at arable farms and of emission reducing techniques is presented separately.

Nitrogen balance/Agriculture/Environmental Policy/Nitrate Directive/Farm level

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PREFACE

The present report is a contribution to the study 'Standards on nitrate in the European Community: Processes of change in policy instruments and agriculture'. The overall objective of the study is to identify (i) policy instruments to reduce nitrate levels in drinking water, such that standards on the quality of drinking water are met; and (ii) processes of change in the agricultural sector of the European Community in response to policies.

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The study is a joint collaboration of the (i) Landbouw-Economisch Instituut (LEI-IEA), Brussels, Belgium; (ii) Statens Jordbrugsøkonomiske Institut (SJI), Copenhagen, Denmark; (iii) Bundesforschungsanstalt für Landwirtschaft, Institut für Betriebswirtschaft (FAL), Braunschweig, Germany; (iv) Institut National de la Recherche Agronomique, Station d'Économie et Sociologie Rurales (INRA), Rennes, France; (v) Landbouw-Economisch Instituut (LEI-DLO), The Hague, the Netherlands; and (vi) University of Stirling (STI), Economics Department, Scotland, United Kingdom.

The report builds upon the report 'Mineral balances at farm level in the European Union', which quantified mineral surpluses and assessed structural characteristics. The present report focuses on the impact of policy instruments on income and nitrogen balances at farm level and assesses processes of change in the agricultural sector in response to these instruments.

Comments on a draft version of the report were received from F.M. Brouwer, J. Post, L. Lauwers and W. Kleinhanss. The author highly appreciates the important remarks made on the report.

The Director,

The Hague, December 1996 L.C. Zachariasse

SUMMARY

Objective of the study

The report is to investigate the impact of agri-environmental policy instruments for the control of nitrate pollution from agricultural sources on income and nitrogen balances at farm level in the European Union. Emphasis is given to policies for the control of nitrate leaching to the available water resources. Insight into the number of farms affected by policy will be provided. Various farming types will be affected by policy in different ways, not only because of differences in farm structure and input use but also because of the way organic manure is treated at the farm. The farming types considered include dairy, granivore and cereal farms.

The availability of information

Calculations at farm level are based on the 1990/91 sample of the Farm Accountancy Data Network (FADN) of the European Commission. The sample includes 58,450 farms which in total represent 4.4 million farms in the EU. Assessments are available for a number of farms of the sample, and are based on individual FADN data. Variable costs per crop for the year 1990/91 are obtained from the Sectoral Production and Income model for agriculture (SPEL). Additional data have been obtained from experts in the Member States.

Method used

A farm Linear-Programming model is developed which integrates economic and environmental elements. It is a suitable instrument to choose between alternatives under CAP Reform. The model maximizes whole farm gross margin. The gross margin provides an indicator for the change in farm income. Environmental elements of policy are incorporated as model constraints. The nitrogen surplus at farm level is used as an indicator for the potential of leaching to soils. The mineral balance is calculated endogenously in the model. Mineral balances in the report are based on the so-called surface balance approach. It reflects the application and treatment of minerals on the field. Input and output flows of manure are considered. Farms are individually optimized to gain insight into the distribution of changes in income and in nitrogen balances among farms.

Only a limited set of adjustment processes is considered in the analysis made, which means that a kind of worst-case scenario is assessed. Focus is mainly limited to nitrogen flows in response to changes of policy. The impact of a number of adjustments in farming practice will be presented separately. Introduction of these adjustments depends on the strategic as well as tactic adaptation behaviour of farmers.

Scenarios assessed

Existing environmental policy regulations in the Member States are considered in the analysis because they already affect farms and contribute to meet environmental standards. The base scenario of the optimized model has to reflect the situation of farms in the 1990/91 data base. CAP Reform at its final stage in 1995/96 is the reference scenario and is part of the other scenarios as well. The with-and-without principle is used to show the effects of policy. A standard on the application of nitrogen from organic manure as well as a levy on the nitrogen surplus will be compared to the CAP Reform scenario. The environmental policy scenarios chosen for the assessment aim to meet objectives formulated in the Nitrate Directive. The analysis focuses on the application standard of 170 kg of nitrogen per hectare from organic manure. This is one of the main elements of the Nitrate Directive. The use of mineral fertilizer is considered in the directive in the codes of good agricultural practises. Therefore a levy on the nitrogen surplus is assessed, which burdens not only the application of organic manure but also the use of inorganic fertilizer.

Nitrogen balance of dairy farms

Supply of animal manure in Europe exceeds 170 kg N/ha (excluding emission losses) on approximately 19% of the number of dairy farms represented by FADN. This is the equivalent of almost 115 thousand holdings. The share of the number of dairy farms with excess of nitrogen from animal manure, affected by a standard on the application of organic manure of 170 kg N/ha, in total number of dairy farms is lowest in Germany, France, Ireland and Luxembourg (less than 5%) and highest in the Netherlands (97%).

The application standard forces dairy farms to dispose organic manure. On average about 16 kg of nitrogen per hectare has to be disposed in addition. It varies largely among the countries. The gross margin is reduced by 1,100 ECU per farm on average considering limited adjustment processes compared to the CAP Reform scenario. At production intensive farms increasing mineral fertilizer use is needed to maintain crop production.

A levy on the nitrogen surplus can be avoided by disposal of organic manure. This is one of the options considered in the analysis. Other options, which might even allow to achieve environmental targets at lower costs, are not considered in the analysis. This could include reducing fertilizer rates, equipment to reduce emissions of ammonia while spreading of manure and reducing protein content of feed. On average about 40 kg of nitrogen per hectare is disposed in addition. It is even higher in Belgium, Denmark and the United Kingdom. The gross margin is reduced by 4,700 ECU per farm on average in EU 12 compared to the CAP Reform scenario. This big reduction in gross margin compared to the application standard results from adjustment processes. A levy on the nitrogen surplus meets the application standard of organic manure of 170 kg N/ha at all dairy farms, except at intensive dairy farms. At these intensive farms only manure which is not needed for crop requirement is disposed, under the levy on the surplus. This means that no additional mineral fertilizer purchases are needed, like under the application standard. The application standard forces farms to dispose organic manure, whereas it is only an alternative under the levy.

Amounts of manure disposed are averages per hectare, whereas dairy farms cover a total area of land of 16.7 million hectare in EU 12. This means that considerable amounts of manure have to be disposed in total at dairy farms under strict policy.

Nitrogen balance of granivore farms

Supply of animal manure in EU 12 exceeds 170 kg N/ha (excluding emission losses) on approximately 87% of the number of granivore farms represented by FADN. This is the equivalent of almost 53 thousand holdings. The share of the number of granivore farms with excess of nitrogen from animal manure, affected by a standard on the application of organic manure of 170 kg N/ha, in total number of granivore farms is lowest in Germany (53%) and Denmark (73%). It exceeds 80% in the other Member States assessed.

Under existing environmental policy about 650 kg of nitrogen per hectare has to be disposed already. Granivore farms cover 0.7 million hectare of land in EU 12.

The amount of manure that has to be disposed under the application standard does not change substantially on average. Granivore farms were already affected by existing environmental policy. The gross margin is reduced by 6600 ECU per farm on average compared to the CAP Reform scenario. Under the levy on the nitrogen surplus the surplus is reduced by some 100 kg N/ha and the gross margin by 9100 ECU per farm on average. The lower gross margin is mainly the result of the higher level of disposal costs assumed under strict policy.

Nitrogen balance of cereal farms

Cereal farms will be affected by the increased supply of surplus manure. Organic manure will be more competitive compared to fertilizer as the pressure on the manure market will increase. Surplus manure will be transferred from surplus farms to farms that still can use manure. Inorganic fertilizers will be replaced by organic manure. The replacement is restricted by the substitution rate. When the rate is based on actual farmers' behaviour, there is a supply of disposal room at cereal farms under strict policy of about 40 kg N/ha, whereas cereal farms cover a total area of 12.5 million hectare of land in EU 12.

Adjustments in farming practice

Several responses are to be expected by farmers to meet the requirements of policy, whereas only flows of organic manure are considered in the results presented above. The nitrogen surplus can also be reduced by lowering the input of mineral fertilizer. Further at dairy farms a better degree of utilization of animal manure under the application standard can maintain crop production, without additional mineral fertilizer use. Another option for farms is to extend their area of land to spread manure on. Processing of organic manure and manure separation are options as well. An overall introduction, however, leads to a decrease of the local disposal pressure and, in consequence, of the original incentives. The impacts of the following three adjustments are assessed by the model separately.

- A more efficient usage of nitrogen in animal feed. This option reduces the nitrogen excretion. Less organic manure has to be disposed under strict policy. The introduction of improved feed concentrates is mainly an interesting option at granivore farms, which face high disposal costs.
- The replacement of inorganic fertilizers by organic manure. Replacement rates used are considered to reflect actual farmers' behaviour. They may increase by allowing for higher application levels of animal manure at the expense of mineral fertilizers, based on what is technically feasible. The replacement may be restricted by environmental policy. Mainly at arable farms a substantial replacement is possible.
- Losses of minerals to the atmosphere can be reduced by emission reducing techniques. Less losses increase the surplus in the short term and more minerals have to be disposed to meet policy requirements. However, in the long term deposition will be reduced as well and the surplus will probably not change.

The introduction of these adaptations depends on the pressure on the manure market, the local level of disposal costs and the costs of an alternative option.

Discussion

The development and implementation of an integrated economic/environmental farm model at an European level is still in its infancy and faces a number of problems. First of all with regard to the incorporation of dynamic responses by farms to policy changes. Besides it is also hard to formulate different environmental policy instruments which meet similar environmental targets. Since the adjustment processes considered in this report are rather limited and disposal costs are exogenously determined, and not all farming types are considered, the results of this approach must be interpreted with the necessary care.

1. INTRODUCTION

1.1 Scope of the study

In the European Union (EU) there is a growing concern about nitrate levels in ground water and the eutrophication of surface and coastal water. Agriculture is one of the main contributors to the pollution of the aquatic environment by nitrates (Rude and Frederiksen, 1994). European Legislation placed a 50 mg/litre limit on the levels of nitrate allowable in drinking water (EU drinking water standard). High nitrate levels are due to the high surplus of nitrogen from agriculture and to vulnerability of the soil to leaching. Major adjustments are required in EU agriculture to reduce leaching of minerals and meet the standards of nitrate. A directive concerning the protection of waters against pollution caused by nitrates from agricultural sources was announced to the Member States in 1991 (Council Directive 91/676/EEC). Member States implement their policies to meet objectives formulated in the directive.

Part of the study 'Standards on Nitrate in the European Community' focuses on the quantitative assessment of agri-environmental policy instruments concerning the nitrogen pollution problem at different levels. In addition to the assessment of policy instruments at national (Hellegers, 1995) and regional (Becker and Kleinhanss, 1995) level this report focuses on the farm level. Due to their level of aggregation regional models are not able to asses the impact of policies related to farm structure. Farm models regarding farm structural characteristics are needed.

Knowledge on the amount of minerals in animal manure is not sufficient for an assessment of leaching potentials to the environment. Mineral balances are more appropriate in that respect, including both inflow and outflow elements. The nitrogen surplus at farm level is used, because this indicator is more appropriate for the identification of the potential of leaching to soils. The relationship between nitrogen surplus and the actual leaching of nitrate is not direct, but also depends on climatic and soil conditions. The balances are identified at farm level since the available options to contribute to a reduction of mineral surpluses primarily prevail there. Adaptations at farm level are needed to meet the objectives of policy.

The main objective of the farm level assessment is to examine the impact of agri-environmental instruments for the control of nitrate pollution from agricultural sources on income and nitrogen balances at farm level in the European Union. The research builds upon the report 'Mineral balances at farm level in the European Union' (Brouwer et al., 1995). Consequences of a restriction on the application of nitrogen from organic manure and a levy on the nitrogen surplus will be analysed for dairy, granivore and cereal farms in 12 EU Member States. The situation in the Netherlands will be highlighted. The environmental policy scenarios chosen for the assessment aim to meet objectives formulated in the Nitrate Directive. Besides environmental policies, the agricultural sector will also respond to alterations in market and price policies. The 1992 Common Agricultural Policy (CAP) Reform contains substantial price reductions combined with compensation payments, which will affect farming practice and farm income. CAP Reform may have an impact on the nitrogen balance and the intensity of farming, due to changes in the cropping plan and the stocking density, and therefore has to be regarded in the assessments as well.

For the purpose of this study a Linear-Programming model at farm level has been constructed. Environmental elements of policy scenarios are incorporated as model constraints. The model maximizes whole farm gross margin of individual farms, which provides an indicator for the change in farm income. The nitrogen balance is calculated endogenously in the model.

1.2 Method used

Simple simulation models might be able to consider adaptation processes if a step by step procedure is used, and the number of production processes and adaptations is quite small. As soon as the farming system becomes more complex, simple simulation models are difficult to use. A Linear-Programming model (LP model) at farm level is designed for the purpose of the study, because it considers adaptation possibilities simultaneously, even if the farming system is more complex. It allows to respect the with-and-without principle in evaluating different policy scenarios. The model has been developed in a joint collaboration effort with FAL. Results of another version of the model for Western Germany are presented in a report by Schleef (forthcoming).

The model allows to quantify the impact of policy instruments and CAP Reform on income and nitrogen balances at farm level. Agri-environmental policy measures are introduced as model constraints. The objective function, which maximizes whole farm gross margin (revenues minus costs) plus net subsidies, provides an indicator for the change in farm income. Ecological impacts are indicated by the change of the mineral balance, which is calculated endogenously in the model. Moreover, new technologies can be implemented in the model by additional activities. The farm model is comparative-static. The general structure of the model has the mathematical form of the familiar Linear-Programming problem:

$$\text{Maximize } \{ Z = c'x \}$$
$$\text{subject to } Ax \leq b$$
$$\text{and } x \geq 0$$

with:
Z = gross margin including net subsidies
x = vector of activities
c = vector of net revenues per unit of activity
A = matrix of input-output coefficients
b = vector of constraints

The activities (see appendix 1) out of which the optimal combination has to be chosen by the solution procedure, are associated with revenues and costs. There are revenues of crops, animals and animal products sold. Revenues are generated by compensatory payments as well, based on area of crops, land set-aside and animals. Costs incorporated are variable machinery costs, seed costs, plant protection costs, expenditures on fertilizer, purchased animals, concentrated feed and roughage. Besides expenditures on the purchase and disposal of organic manure are included.

The model covers 12 EU Member States. This provides insight into major processes of change across the EU. Running the model with average farms shows how an average farm might react and reduces the number of optimizations considerably. Model optimizations of individual farms, however, are necessary to gain insight into the distribution of changes in income and in nitrogen balances among farms and to show extreme cases. Therefore, individual farms are optimized. In each run of the model some right-hand side coefficients depend on the farm as well as some of the coefficients of the objective function.

The software used for solving the Linear-Programming model is Sciconic. It contains the LP-problem formulation.

The model can be used for most kind of farming types, except horticultural holdings, vineyards and permanent crop holdings. This is mainly because the available knowledge of mineral requirements and mineral uptake of horticultural and permanent crops is rather limited. Nevertheless it is known that considerable amounts of animal manure are applied on some horticultural crops. For each farming type distinguished (section 3.1) results of weighted averages of individual optimized farms will be presented by Member States. A more detailed assessment is made for farming types in regions with considerably higher nitrogen surpluses than the national averages. Classification by farming type, region and manure production per hectare, allows the examination of whether groups of farms of a farming type in a region would already be able to meet the requirements of policy. It reflects the main structural and regional characteristics which are critical to the flows of minerals at farm level. Averages can be compared to more extreme conditions.

The concept of mineral balances used, is based on the surface balance approach. The assessments are based on the elaborations to assess mineral balances at the regional level (Schleef and Kleinhanss, 1994) and at farm level (Brouwer et al., 1995). Differences however arise with assessments published before. For the purpose of the present research a correction on the surplus is made for the amounts of manure disposed and purchased (see appendix 4). Besides, emission losses are assumed to be 20% instead of 30%. Furthermore, the application standard assessed in the present report excludes emission losses. These losses were not excluded by Brouwer et al. (1995).

Excretion, uptake and requirement coefficients used are presented in appendix 3. They are based on the figures used by Brouwer et al. (1995). There are two exceptions to this. First, for Belgium the excretion figures of the Netherlands are used because excretion levels of Belgium used by Brouwer et al.

(1995) were substantially below more recent estimates. Second, excretion levels of dairy cows are differentiated. They depend on the milk yield in the present report (see appendix 3).

Mineral balances and their components are presented in the report in kilogram per hectare unless otherwise stated. The denominator is based on the area of arable crops and grass. This area is considered to be available for the application of manure. The area does not include permanent crops. The total utilized agricultural area (UAA), including arable crops, permanent grass and permanent crops, is only used in the report if it is explicitly stated. The gross margin is presented per farm unless otherwise stated.

1.3 Data sources used

The assessment at farm level are based on the 1990/91 sample of the Farm Accountancy Data Network (FADN) of the European Commission. The sample includes 58,450 farms that in total represent 4.4 million farms in the EU. Data are available for all farms of the sample. Optimizations are based on individual farm data. The report only provides results of averages of at least fifteen farms. FADN contains farm level data on e.g. gross margin, farming type, number of farms represented, regional location and whether this is a Less Favoured Area. Data used for the farm level assessment are further area under a crop, number of animals, variable input use, the milk quota and yields of crops and animal production. FADN is not able to distinguish between management characteristics of farms like ways of treating manure. It contains only a restricted number of variables. Additional data like prices of in- and outputs and some technical coefficients are provided by the participants of the study.

Variable costs (of machinery, seed and plant protection products) per crop for the year 1990/91 are obtained from the Sectoral Production and Income model for agriculture (SPEL/EC) 1). These variable costs per crop are aggregated to the farm level and adjusted to actual expenditures on machinery, seed and plant protection at the farm provided by FADN. These adjusted variable costs reflect the endowment of the farm. The endowment is also reflected in the input of feed concentrates per animal. Standard input coefficients of concentrated feed input for pig and poultry are adjusted to the actual total expenditures on pig and poultry concentrates provided by FADN. The actual expenditures on cattle feed concentrates are only reflected in the input of feed concentrates of dairy cows. For other cattle standard input coefficients are used. The corrections to actual expenditures are restricted.

The use of mineral fertilizer is not recorded at crop level by FADN. Farm specific information regarding the total expenditures on inorganic fertilizer is reflected in the requirement of minerals per crop. First of all mineral require-

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1) The concept of the SPEL/EC System was developed at the Institut für Agrarpolitik, Marktforschung und Wirtschaftssoziologie of the University of Bonn by Henrichsmeyer, Wolf and Greuel (Wolf, 1992).

ment is calculated by normative requirement functions, based on the yield of crops. Then the maximum from organic manure in total mineral requirement is calculated for each crop and subsequently for the whole farm. It is assumed that the amount of phosphate and potassium provided by organic manure at the farm is completely available for plant growth. Further it is assumed that the amount of these minerals required for plant growth that still lacks, originates from mineral fertilizer. Costs of phosphate and potassium can be calculated and subtracted from the mineral fertilizer expenditure. The amount of inorganic nitrogen can now be derived. In case organic manure is produced at the farm the requirement of nitrogen fertilizer is adjusted to the expenditures on fertilizer provided by FADN. Otherwise, the requirement of phosphate and potassium is adjusted. The adjustments are within certain ranges.

Yields of field crops are partly available in FADN. Regional averages of yields of field crops from the REGIO-Data Bank of Eurostat have been used in case yields were not available at farm level. Regional yields have also been used when farm yields deviate too much from the regional yields. Yields of forage crops originate from external sources (Schleef and Kleinhanss, 1994).

1.4 Strength and weakness of the model

An advantage of the farm model is that differences between farms can be assessed, which provides insight into the variation of changes among farms. Individual farms are optimized instead of averages of farms because farms are not homogenous. The average application of nitrogen from organic manure per hectare in a region may not exceed a certain level, whereas part of the farms exceeds this level. These farms will be affected by policy. The model is able to provide insight into the distribution of changes in income and in nitrogen balances among farms and shows which farms are affected mostly in the European Union by policy measures. Another strong point of the model is the way CAP Reform is incorporated. Although extensification of crop production due to a lower input use of fertilizer is not considered in the framework of the model.

A limited set of farm adjustment processes is considered in this report. The adjustment processes do not intend to reflect the wide range of possible adaptation processes of individual farmers. They aim to address changes of nitrogen flows in response to changes of policy. Since the Nitrate Directive mainly aims to reduce the amount of manure applied focus in this project is limited to nitrogen flows, in terms of excess amounts of manure produced which need to be disposed and amounts of manure which can be purchased. More detailed investigations allowing for dynamic responses by farms would have been very resource consuming, require major additional sources of information and knowledge on technical-economic relationships in the various regions and farming types investigated. A broad set of adaptation processes were recently explored in the Netherlands in an investigation to assess socio-economic consequences of various alternatives to phosphorus and nitrogen losses (Nieuwenhuize et al., 1995).

A likely adaptation not considered in the analysis is an increase in the area of land to spread manure on. For example granivore farms with only one hectare (ha) of land and high surpluses can halve the surplus per hectare by buying or renting another hectare of land. However, the total area of land available for agricultural purposes in a region is restricted.

A farm Linear-Programming model has been used as a tool. The model is a pure supply model, market interactions are not considered. This implies among others, that the level of the disposal and purchase costs of animal manure are exogenously determined. The model is comparative-static, whereas farmers respond in a more dynamic way. Therefore not only results of the model are shown, but an attempt is made to provide a plausibility in reasoning. Attention is paid in this respect to exogenously determined variables of the model and to relations between variables. For example to the aspects which determine the level of the disposal costs and to the level of the levy on the nitrogen surplus in relation to the level of the disposal costs. Besides attention is not only paid to the consequences of adjustments in farming practice in response to policy but also to the conditions for introducing it. Since macro-effects are not considered in this micro-approach, model outcomes have to be compared to other approaches. To analyse supply and demand effects with regard to regional conditions, national and regional models (Becker and Kleinhanss, 1995) are necessary.

1.5 Outline of the report

The report proceeds as follows. The method and data used and the possibilities and limitations of this method are described in this chapter. Next in chapter 2 the policy scenarios assessed are outlined. Chapter 3 contains a further specification of the model and of the assumptions made. Chapters 4, 5 and 6 present results of the impact of policy measures concerning the control of nitrate pollution on the farming types distinguished. Chapter 7 shows the consequences of adjustments in farming practice. In the final chapter some concluding remarks of the study are presented.

2. POLICY INSTRUMENTS

2.1 Introduction

Policy instruments are assessed at three different levels in the study (figure 2.1). In addition to the assessment at the national (Hellegers, 1995) and regional (Becker and Kleinhanss, 1995) level this report focuses on the farm level. A standard on the application and a levy on the nitrogen surplus are assessed at farm level. The choice of these scenarios will be described in section 2.3. At regional level the application standard is not assessed. The average regional manure production does not exceed the assessed application level per hectare very often. Manure production, which exceeds this level is concentrated at groups of farms. At regional level it is examined whether the surplus can be reduced by a levy on fertilizer.

Scenario	National	Regional	Farm
Base situation	X	X	X
CAP Reform	X	X	X
A levy on fertilizer		X	
An application standard			X
A levy on the nitrogen surplus			X

Figure 2.1 Scenarios and level of assessment
Source: LEI-DLO.

The base scenario of the optimized farm model has to reflect the situation of farms in the 1990/91 data base. The farm data assessed concern a time period before CAP Reform, whereas the model is specified for a projection of policy changes for the production year 1995/96 when CAP Reform is fully implemented and environmental policy assessed is assumed to be fully implemented. For this reason, CAP Reform at its final stage has to be formulated as a scenario, the reference scenario. The reform scenario will be described in section 2.2. CAP Reform is part of the application standard and levy on nitrogen surplus scenarios as well, since it will last during the next years. Figure 2.2 shows the level of comparison between the scenarios. The CAP Reform scenario has to be compared to the base scenario to show the impact of the reform. While the levy on the nitrogen surplus and the application standard have to be compared to the CAP Reform scenario to show the impact of environmental policy.

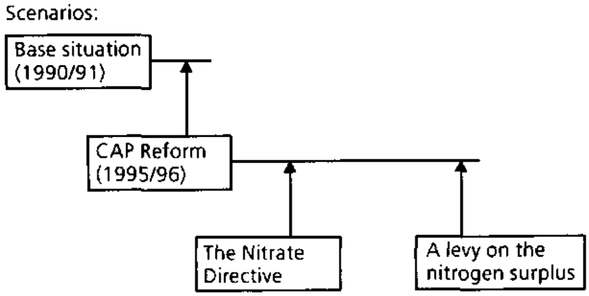

Figure 2.2 Scenarios and level of comparison
Source: LEI-DLO.

Environmental regulations which affect farms already exist in the Member States. Present agri-environmental policies, as identified in the report on 'National and EC Nitrate Policies' (Rude and Frederiksen, 1994), have to be considered in the analysis because they already contribute to environmental standards. Besides, it shows whether supplementary implementation of policy is needed. Policy measures implemented before 1995/96 are considered in the analysis in a simplified way. Existing policy in Belgium and the Netherlands incorporated in the model focuses on phosphate in organic manure. It is assumed that the application of animal manure should not exceed 125 kg P_2O_5/ha for arable crops and 175 kg P_2O_5/ha for grass and fodder maize (in the Netherlands in 1996/97 standards are respectively 110 kg P_2O_5/ha for arable land and 135 kg P_2O_5/ha for grassland). In Germany and Denmark existing policy focuses on nitrogen in organic manure. Maximum application standards of animal manure considered for both countries are 200 kg N/ha, excluding emission losses (in Germany there is a Düngeverordnung since 1996, limits for organic fertilizer are 210 kg N/ha for grassland and 180 kg N/ha for arable land). In other Member States animal manure application standards, excluding emission losses, of 350 kg N/ha for grassland and of 200 kg N/ha for arable crops and fodder maize are assumed.

2.2 CAP Reform scenario

In the CAP Reform scenario linkages among the adjustments in market and price policies and the leaching potential of nitrate are made. The 1992 CAP Reform can be distinguished between market and price policy and set-aside requirements. CAP Reform reduces price support, replacing it by compensation payments per hectare and per animal (Folmer et al., 1995). The assumed price reductions of some outputs under the reform, are shown in table 2.1. The price

Table 2.1 Price changes of outputs (%) under conditions of the CAP Reform in the European Union

	Milk	Cereals	Pulses	Oil seeds	Cattle	Pigs	Sheep & goats	Poultry	Eggs
EU 12	-2	-30	-43	-48	-12	-6	-2	-11	-10

Source: Becker and Kleinhanss, 1995.

Table 2.2 Price changes of feed concentrates (%) under conditions of the CAP Reform by Member State

	Belgium/ Luxembourg	Denmark	Germany	Greece/ Spain/ Portugal	France	Ireland	Italy	Netherlands	United Kingdom
Feed concentrates	-11.25	-16.95	-15.54	-19.10	-15.97	-10.97	-16.34	-6.51	-16.09

Source: Becker and Kleinhanss, 1995.

reductions of feed concentrates are presented by Member State in table 2.2. The assumed price changes are exogenously determined in the model and are in conformity with the figures used by Becker and Kleinhanss (1995). The impacts of changes in the market regimes on the environment are likely to differ among regions in the EU.

Under the arable sector reform, production-oriented support is replaced by direct producer payments coupled with set-aside requirements. Farmers producing more than 92 tonnes of cereals, oil seeds and protein crops not applying for the small-scale producer scheme, have a 10 per cent set-aside obligation in order to receive compensation on a per hectare basis. The compensation payments are for cereals 45 ECU per tonne, for oil seeds 152 ECU per tonne and for set-aside acreage 57 ECU per tonne. One of the objectives of the reduction in cereal prices is to redress competitiveness of cereals used in animal feed. The consumption of animal feed cereals produced in the European Union becomes more attractive under the CAP Reform in comparison to the use of imported feed concentrates. Competitive advantages of fattening pigs in areas close to harbours, like in the Netherlands and Flanders, may diminish (Brouwer and Van Berkum, forthcoming). The price reduction of feed concentrates in countries which import cheap grain substitutes is smaller than the reduction in countries with a considerable share of European grown cereals in animal feed consumption. The reduction of the price of cereals affects the composition of feed concentrates, and subsequently also mineral levels in animal manure. Knowledge available of the impact of another composition of feed due to the reform on mineral excretion levels of animals is rather limited and is not considered in the analysis.

Under the livestock sectors reform of beef, the reduction in the output price is partly compensated by payments based on the number of livestock on the farm. Male cattle receive annually 90 ECU compensation per head and suckler cows 120 ECU per head up to a maximum headage ceiling of 90 premiums. These premiums are paid for stocking densities up to 2 Livestock Units (LU) (eligible for premiums) per hectare. Additional premiums are paid if stocking density is less than 1.4 LU/ha. Such density related payments may contribute to reduced levels of animal manure. The reform of sheepmeat concentrates on a maximum headage ceiling for the annual ewe premium.

Output price changes, like lower prices of cereals and oil seeds under the reform induce changes in the optimal cropping plan and livestock composition. These adaptation possibilities are considered by the model. The impact of the reform on the use of fertilizer will be modest. Changes in fertilizer use due to CAP Reform are mainly caused by the set-aside scheme. Extensification of crop production due to a lower input use of fertilizer is not considered in the framework of the model. Intensity adjustments like changes in the livestock density can take place.

2.3 Environmental policy scenarios

The environmental policy scenarios chosen for the assessment aim to meet objectives formulated in the Nitrate Directive. This directive, concerning the protection of waters against pollution caused by nitrates from agricultural source, was announced to the Member States in December 1991 (Council Directive 91/676/EEC). The main objective of the directive is to prevent or reduce the pollution of waters by nitrate from agricultural sources. Nitrate concentration in groundwater is highest in regions with intensive livestock production and may not exceed the, by the EU legally accepted, limit of 50 mg per litre. The Nitrate Directive includes regulations on how to handle manure in zones which are identified to be vulnerable to the leaching of nitrate. Some Member States (Belgium, Denmark, Germany, Luxembourg, the Netherlands and the United Kingdom) so far identified such zones. These countries, with the exception of the United Kingdom, consider that the whole territory needs to meet the requirements of the directive. In the other Member States, it is not clear at the moment which zones will be identified. One of the main elements of the directive is that the application of animal manure in vulnerable zones should not exceed 170 kg of nitrogen per hectare. This standard on the application of organic manure, which is part of the directive, is formulated as a scenario. The Nitrate Directive will be fully implemented by the year 2003. A four-year's transition period (1996-1999) is identified in the Nitrate Directive. During this period a maximum of 210 kg of nitrogen per hectare from organic manure may be considered by the Member States. The standard should be met at farm level unless the goals formulated in the directive could be achieved through other instruments. The Nitrate Directive also considers the use of mineral fertilizer in the codes of good agricultural practises. Therefore a scenario is formulated (a levy on the nitrogen surplus) which burdens both inputs, the application of organic manure and the use of inorganic fertilizer.

At farm level a standard on the application of organic manure and a levy on the nitrogen surplus will be assessed, whereas other options would have been a levy on fertilizer and a livestock density restriction.

The impact of a levy on fertilizer on the purchase of fertilizer depends not only on the price elasticity of mineral fertilizer but also on the a priori assumed substitution rate between mineral and organic fertilizer (Becker and Kleinhanss, 1995). If there is a relatively inelastic demand for fertilizer (England, 1986) a relatively high levy on fertilizer is needed to achieve the reduction in fertilizer use. A higher price of fertilizer may induce more extensive production methods. However, adjustments of the yields are not considered within the framework of the model. Yields are determined outside the model and are considered to be fixed. Input-output relations are considered to be fixed. Moreover a levy on fertilizer provides an incentive to increase the use of organic manure, while this Nitrate Directive restricts the application of nitrogen from organic manure.

Mainly at intensive livestock farms the livestock density restriction is not a suitable policy instrument. A density restriction reduces the number of animals substantially and contributes to reduced levels of animal manure. Farming practice will be more extensive. The adaptation possibilities of the farm are limited. Disposal of manure is not an appropriate solution to the problem. Therefore, this scenario is not assessed.

A standard on the application of nitrogen from organic manure

A standard on the application of nitrogen from organic manure is a command-and-control based policy instrument. Under the application standard scenario only 170 kg of nitrogen from animal manure (excluding 20% emission losses) may be applied per hectare, the remaining amount of manure has to be disposed. Disposal of manure is directly related to the high concentration of livestock production. It is assumed here that the whole territory has to meet this standard to indicate problems in regions not identified as vulnerable zone to the leaching of nitrate so far. CAP Reform is part of this scenario.

A levy on the nitrogen surplus

A levy on the nitrogen surplus is a market-conformed instrument. It does not meet standards on forehand. CAP Reform will be part of this scenario as well. The level of the levy per kilogram of nitrogen surplus may increase more than proportionally (prohibitive) with increasing surplus to provide a stimulus to reduce very high surpluses to lower levels. In the present report the levy is assumed to be constant and is 3 ECU per kilogram nitrogen surplus (in section 3.2 the level of the levy is derived) and includes a 'levy free zone' of 100 kg of nitrogen surplus per hectare. This zone is derived from the limit chosen by Wendland et al. (1993) to identify regions vulnerable for nitrate leaching. Although they point out that geological and climatic conditions have to be taken into account to judge nitrogen surpluses. Under a levy on the surplus, organic manure can be disposed in the analysis to reduce the surplus and to avoid the levy.

3. MODEL SPECIFICATION

3.1 Farming types distinguished

To gain insight into which farms contribute to the nitrate pollution of a Member State, the distribution of the total nitrogen surplus among farming types is presented in table 3.1. More than 30% of the total nitrogen surplus of the Member States is produced at dairy farms in Germany, Ireland, Italy, Luxembourg and the Netherlands and at drystock farms in Greece and Ireland. Mixed farms in Belgium, Denmark, Germany and Portugal exceed also this percentage. In Spain, France and the United Kingdom surpluses are less concentrated at a particular farming type. In EU 12 about 75% of total nitrogen surplus is located at general cropping, dairy and mixed farms.

Table 3.1 Share (%) in total nitrogen surplus of a Member State per farming type in 1990/91

Country	Cereal	General cropping	Dairy	Drystock	Granivore	Mixed
Belgium	.	14	27	15	12	32
Denmark	6	23	27	.	12	32
Germany	2	19	37	6	1	35
Greece	7	28	2	41	4	17
Spain	9	9	10	24	26	21
France	11	27	21	14	4	23
Ireland	2	2	48	41	.	7
Italy	2	2	33	20	19	25
Luxembourg	.	.	61	16	.	22
Netherlands	.	24	47	5	13	10
Portugal	0	14	19	6	21	41
United Kingdom	20	21	22	20	4	13
EU 12	6	21	29	14	7	23

Note: If the minimum threshold of 15 farms for the sample size is not reached for a farming type, no data are given.
Source: FADN-CCE-DG VI/A-3; adaptation LEI-DLO.

To gain insight into whether these surpluses are equally distributed among farms, the share of a farming type in total number of farms is needed (table 3.2). The largest part of the nitrogen surplus (29%) is produced at dairy farms, which have only a share of 13% in the total number of farms. At granivore farms 7% of the nitrogen surplus is located, whereas the share of granivore farms in total number of farms is only 1% (table 3.2). This means that surpluses per farm are relatively high at dairy and granivore farms.

Table 3.2 Share (%) in total number of farms represented by Member State per farming type in 1990/91 a)

Country	Number of frams represented (x 1,000)	Cereal	General cropping	Dairy	Drystock	Granivore	Mixed
Belgium	51.9	.	15	26	1	17	28
Denmark	81.0	15	30	19	.	6	26
Germany	373.9	2	15	35	5	1	33
Greece	498.3	6	42	1	10	0	8
Spain	690.6	15	22	9	14	2	12
France	556.7	6	20	23	17	2	17
Ireland	140.2	3	2	40	51	.	5
Italy	1,369.8	7	35	6	6	0	10
Luxembourg	2.3	.	.	57	14	.	20
Netherlands	94.0	.	15	40	5	10	9
Portugal	448.5	2	37	6	9	1	32
United Kingdom	141.6	11	15	25	31	3	11
EU 12	4,448.9	7	28	13	11	1	15

a) The shares of the other farming types (horticultural holdings, vineyards and permanent crops) are not presented.
Note: If the minimum threshold of 15 farms for the sample size is not reached for a farming type, no data are given.
Source: FADN-CCE-DG VI/A-3; adaptation LEI-DLO.

Nitrogen surpluses are used as an indicator of the nitrate problem in the present report. A reduction in the nitrogen surplus can be achieved by disposal of manure, which can be purchased by other farms. Table 3.2 provides insight into the number of potential suppliers and demanders for disposal room within the country. The distribution of the number of farms represented among the six farming types distinguished varies across Member States. The number of farms with crop production (cereal and general cropping farms, which can be regarded as potential suppliers for disposal room) exceeds the share of farms with livestock production (dairy, drystock and granivore farms, which can be regarded as potential demanders for disposal room) in Denmark, Greece, Italy and Portugal (table 3.2).

For the purpose of the research three farming types are distinguished, with respect to the different ways organic manure is treated at the farm. These concern dairy, granivore and cereal farms. At dairy farms manure produced at the farm is mainly applied at the farm (soil dependent livestock production). However, a large share of manure produced at granivore farms is applied outside the farm (soilless production). At cereal farms organic manure input originates hardly from manure produced at the farm, but mainly from outside the farm.

3.2 Costs of disposal of animal manure

Determinants of disposal costs

The price of organic manure is a crucial factor in the analysis. Disposal costs per tonne manure depend on the allowable level of minerals, the pressure on the manure market, the acceptance by arable farms, the costs of processing of manure, export possibilities and the distance of manure transports (Nieuwenhuize et al., 1995). Since processing of manure does not take place at a large scale it is not considered in the assessments made. Besides, insight into export possibilities in the regions is rather limited. The impact on the price is therefore ignored. Further disposal costs are independent of the distance of transportation in this report. In reality disposal costs will be differentiated to the distance of manure transport, which differs among regions. In Denmark and Bretagne no transport of animal manure takes place over long distances, because there are sufficient possibilities to apply manure surplus at short distance (less than 15 km), whereas in Flanders and the Netherlands transport over longer distances is required. The acceptance by arable farms depends among others on the quality of the manure which is determined by the nitrogen level per tonne and the nitrogen/phosphate ratio.

In case the usage of organic manure is restricted by standards on the application of organic nitrogen, the nitrogen/phosphate ratio of organic manure will determine the amount of phosphate which can be applied. This ratio depends on the animal origin of the manure, the feed composition and the way organic manure is stored. Adaptations induced by environmental policy will change the nitrogen/phosphate ratio. Under a nitrogen application standard, it is preferable to have animal manure which contains a high amount of phosphate per kilogram of nitrogen, given that the Member States do not have standards on the application of phosphate. However, in case policy focuses on phosphate as well, like in the Netherlands, the nitrogen/phosphate ratio is important towards finding a balanced maximum organic nitrogen and phosphate fertilization.

Since insight into the manure market interactions in the regions is rather limited, the levels of disposal and purchase costs of animal manure are exogenously determined in the model and there is no differentiation between Member States. Under stricter policy, changes in the level of the costs are exogenously determined in the model as well.

In case policy focuses on nitrogen, this mineral is the determinant for the level of disposal costs. In the approach used here disposal costs are accounted per kilogram of nitrogen. Since the nitrogen contents per tonne of manure vary per animal species and disposal costs are accounted for per kilogram of nitrogen, disposal costs per tonne of manure are distinguished to its animal origin.

The level of disposal costs

The level of the disposal costs is based on the Dutch situation. Total manure production was about 88 million tonnes in 1991 in the Netherlands while the total nitrogen production was 616 million kilograms (Poppe et al., 1994b). So, one tonne of organic manure contains on average about 7 kg of nitrogen in the Dutch situation. Disposal costs of organic manure (including transportation costs) from surplus area to deficit area are on average about 7 ECU per tonne in the Netherlands (Nieuwenhuize et al., 1995). This level of 1 ECU disposal costs per kilogram of nitrogen is used in the base and CAP Reform scenario. More severe environmental policies may increase disposal costs to even 14 ECU per tonne (Nieuwenhuize et al., 1995). In order to come to these costs, a level of 2 ECU per kilogram of nitrogen disposed is necessary. This level is applied here under the application standard and under a levy on the nitrogen surplus.

The level of the levy on the nitrogen surplus

The level of the levy is derived from the disposal costs. If the level is relatively low compared to the disposal costs no organic manure will be disposed, the levy is paid. However if it is relatively high all organic manure will be disposed to avoid the levy. For a levy to be an efficient instrument, the level of the levy has to be tuned to the disposal costs in other words to the pressure on the manure market. To bring about a better distribution of organic manure among farms the level of the levy has to be above the level of the disposal costs (2 ECU). The level of the levy is assumed to be 3 ECU. Manure is disposed in case the costs of the levy exceed the total costs of disposal plus additional purchases of N, P and K fertilizer, necessary to replace the minerals in manure disposed. Under a levy on the nitrogen surplus manure transfers between farms only take only place in case farms have a 'levy free zone' or in other words, in case their additional organic manure use is not burdened by the levy on the surplus.

Sensitivity analysis of disposal costs

The level of the disposal costs is an important factor in the assessment. Therefore some sensitivity analyses are done with different disposal cost levels for dairy farms in the Netherlands (table 3.3). The calculation of the nitrogen balance is explained in appendix 4 (for dairy farms in the Netherlands). At disposal costs of 1 ECU per kilogram, the 3 ECU levy per kilogram of nitrogen surplus is avoided, all excess manure is disposed. Disposal costs of 2 ECU plus costs for purchase of fertilizer are similar to the costs of the levy. Some farms dispose manure while other farms pay the levy. At disposal costs of 3 ECU per kilogram almost no manure is disposed, the levy is paid. This level has only impact on the gross margin while the aimed further re-allocation of organic manure among farms is not achieved. At disposal costs of 8 ECU hardly any manure is disposed of under the levy, it is cheaper to pay the levy. Under the application standard the livestock density decreases and the livestock composition changes, while the gross margin is substantially reduced.

Table 3.3 Gross margin per farm (x 1,000 ECU) and nitrogen balance (kg N/ha) at different levels of disposal costs (ECU per kilogram of N disposed) on dairy farms in the Netherlands

	Application standard				Levy on surplus			
	1 ECU	2 ECU	3 ECU	8 ECU	1 ECU	2 ECU	3 ECU	8 ECU
Gross margin	82.2	79.5	77.1	67	69.9	67.8	66.9	66.5
Nitrogen surplus	262	262	262	262	101	291	319	327
Deposition	36	36	36	36	36	36	36	36
Manure production	346	332	325	298	346	341	337	332
Purchase of fertilizer	246	246	246	246	309	216	216	216
Uptake by crops	188	189	188	188	188	189	189	189
Manure disposed	109	97	92	70	333	45	13	2
Livestock density (LU/ha)	2.9	2.8	2.7	2.4	2.9	2.8	2.8	2.7
of which dairy cows (%)	56	57	60	69	56	57	60	62
of which pigs & poultry (%)	15	12	11	5	15	12	11	8

Source: Farm Model results LEI-DLO.

Assumptions made with regard to the disposal costs

The assumptions made with regard to the disposal costs are summarized below.

- Disposal costs are assumed to be 1 ECU per kilogram of nitrogen in the base and reform scenario. Under strict environmental policy more manure has to be disposed in regions with high concentration of manure production. The costs of disposal per kilogram will increase. Costs of 2 ECU per kilogram of nitrogen from manure disposed of are assumed under the application standard and under a levy on the nitrogen surplus scenario for the whole EU.
- Purchase costs of organic manure are assumed to be 1 ECU per kilogram of nitrogen in the base and reform scenario. These are assumed to be lower under the application standard and under a levy on the surplus because more manure has to be disposed. If the supply of manure is relatively high, manure may be even received for free. It is assumed that this will be the case at cereal farms under the application standard and under a levy on the surplus. Although this will not be justified in or within all Member States (section 8.3).

3.3 Assumptions of the model

The model includes a set of options and constraints. Restrictions are based on several assumptions. Assumption made with regard to the disposal costs were already presented in section 3.2. The most important assumptions made with regard to the scenarios assessed are summarized below.

The base scenario

The base scenario of the optimization model has to reflect the situation of farms in the data base, therefore some assumptions are made with regard to the structure of farms.

- Regarding the arable sector, the area under a crop is restricted by the original use of the area. If the particular crop was not part of the cropping plan, the area under that crop can be at most 15 per cent of the area arable. The total area of land of a farm may not be extended. Crop rotation schemes are considered.
- The number of livestock units of groups of animals (cattle, pigs, poultry and sheep) may not exceed the original number of livestock units of these groups (appendix 2 shows the coefficients used to convert species of livestock to livestock units). Within these groups of animals substitution is allowed. The replacement rate and the share of losses are considered. The matrix maintains some proportions between animals to come to the number of animals purchased and sold.
- The modelled farms are not allowed to switch to other production activities. For example a cereal farm without livestock production originally cannot start raising poultry.
- Milk production is constrained by the milk quota. Exchange of ownership and user rights is not allowed.
- It is assumed that labour is not a constraint in the model and that the fixed factors remain constant. Investments in capital are not allowed. Knowledge available of costs of environmental investments in the Member States is rather limited. The area of land is assumed to be fixed, it is not allowed to buy land, neither it is allowed to rent land. An increase of utilized agricultural area would have implications for labour requirements which is considered not to be a constraint.
- The variable costs per hectare (of machinery, seed, plant protection) remain constant.
- The factor endowment of the farm is assumed to be fixed during the projection period.
- Farm specific yields used are exogenously determined in the model, which means that the model does not consider extensification of crop production. However, the influence on the gross margin will be marginal as farmers will only use less inputs if this is beneficial from cost-benefit point of view or in other words if extensification allows to maintain their income level.
- As regards the total energy requirement, it is assumed that pigs and poultry obtain only energy from concentrated feed while cattle and sheep obtain also energy from roughage crops.
- There are possibilities for farmers to purchase and dispose organic manure.

- Existing environmental regulations in Member States like described in section 2.1 are considered in all scenarios assessed.
- The model does not generate farming type specific adjustment possibilities.

CAP Reform

The farm data used regard a time period (1990/91) before CAP Reform is fully implemented. Therefore, CAP Reform at its final stage in 1995/96 has to be formulated as a scenario.

- CAP Reform is assumed to be fully implemented. The transition period is ignored.
- For the assumed price reductions under the reform reference is made to section 2.2.
- Under the reform the area of a crop can be extended by 10%, compared to the original area of that crop, although the total area of land of the farm may not be increased.
- Farmers producing more than 92 tonnes of cereals, oil seeds and protein crops have a 10% set-aside obligation under the reform to receive compensation on a per hectare basis. However, spreading of manure is not allowed on land set-aside. It may affect leaching of nitrogen. In case they apply for the small-scale producer scheme they get only compensation payments related to 92 tonnes.
- Farmspecific cereal yields have been used in the analysis to approach the production of 92 tonnes as good as possible. Regional yields are used in case of missing farm yields.
- Diversification towards other activities like non-food rape on land set aside only makes sense if the marginal gross margin of the new crops is higher than the marginal net-return of set-aside. Production risks of cereals have been decreased by the reform (as only a part of the income comes from the market), more risky speculations require even a higher gross margin before they are adopted (Van Huylenbroeck et al., 1995). Therefore no substitution of set-aside by non-food crops is assumed.

The application standard

- The 170 kg N/ha from organic manure that can be applied under the application standard scenario excludes emission losses. These are assumed to be 20% of total nitrogen from manure production. This means that in the analysis made 213 kg N/ha from organic manure produced is allowed.

The levy on the nitrogen surplus

- The level of the levy on the nitrogen surplus is assumed to be 3 ECU for each excess kilogramme of nitrogen above the 'levy free zone' of 100 kg of nitrogen surplus per hectare.

3.4 Outline of the results

The model assesses two environmental policy instruments for the control of nitrate pollution. The results of a restriction on the application of organic manure and a levy on the nitrogen surplus are presented, together with a base and CAP Reform scenario. The analysis shows differences in costs and balance components. The results of chapter 4, 5 and 6 show which dairy, granivore and cereal farms are likely to be affected most and how much organic manure has to be disposed to meet requirements of policy. Besides it shows which farms already meet policy requirements. Dairy and granivore farms are demanders for disposal room, while cereal farms supply disposal room.

The base scenario of the optimized model should reflect the situation of farms in the 1990/91 data base. Verification took the form of a comparison of the observed and solution levels of a number of key variables. The deviation between both values of these variables was modest. Farms which showed some deviation are not ignored. The bias between the optimized model results and the observed situation at the farm in the data base is due to imperfections of the model, it is a simplification of reality. The model results reflect a short term equilibrium and is based on the consideration that all farmers are efficient.

Average inflow and outflow figures of manure per farm, which will be presented in the next chapters, can be aggregated to total amounts per farming type. Demand for disposal room can be compared to supply of disposal room. However, the results of this normative approach have to be interpreted with the necessary care because only three farming types (dairy, granivore and cereal farms) are assessed. Besides not all possible adjustments in farming practice are considered, it is a kind of worst-case scenario.

4. NITROGEN BALANCE OF DAIRY FARMS

4.1 Introduction

Mineral balances differ largely among farms because of differences in farm structure (e.g. cropping plan and livestock composition) and management factors. Balances at farm level therefore are presented by farming type. In this chapter an European assessment on the impact of policy on income and nitrogen balances is presented for dairy farms. The information provided includes national weighted averages of the balances of individual optimized dairy farms. For each country 100 randomly chosen dairy farms are optimized. The only exception to this is Greece, since the FADN sample of dairy farms contains less than 100 farms in that country. The average farm structure of these farms is presented by Member State in section 4.2. Section 4.3 provides insight into the number of dairy farms affected by the application standard. A more detailed assessment of the impact of policy is made in regions with considerably higher nitrogen surpluses than the national averages. Three groups of farms are distinguished in these regions, according to the production level of animal manure per hectare. This allows the examination of whether groups of dairy farms would already be able to meet the requirements of policy. Farm structure characteristics of the groups of farms are important phenomena in this respect which will be examined. Structure characteristics like utilized agricultural area, livestock density and livestock composition are presented. Some concluding remarks are presented in section 4.4.

4.2 Impact of the policy instruments

The weighted average farm structure of the selected dairy farms is presented by Member State in table 4.1. The gross margin and nitrogen balances of these farms under the scenarios assessed are presented by Member State in appendix 5. Some of these results are presented graphically in diagrams in figure 4.1 and 4.2. The weighted average gross margin and nitrogen balance of all selected individual optimized dairy farms in the EU are presented in table 4.2.

Under the scenarios assessed the cropping plan and livestock composition do not change substantially. At a higher levy level and disposal-costs level, both change (section 3.2). The change of the livestock density is reflected in the change of manure production per hectare.

Table 4.1 Farm structure of dairy farms in the Member States

Country	Utilized agricultural area (ha)	Livestock density (LU/ha)	of which dairy cows (%)	of which pigs & poultry (%)
Belgium	27	2.4	57	6
Denmark	35	1.9	57	4
Germany	28	1.5	54	5
Greece	6	3.1	65	0
Spain	7	2.0	69	2
France	39	1.2	60	2
Ireland	35	1.5	51	0
Italy	13	1.7	66	0
Luxembourg	51	1.4	50	2
Netherlands	28	2.9	56	15
Portugal	9	1.5	63	1
United Kingdom	60	1.8	63	0
EU 12	28	1.8	57	4

Source: Farm Model results LEI-DLO.

Utilized agricultural area at dairy farms in Greece, Spain and Portugal is less than one third of the average in EU 12. Animal density of dairy farms exceeds 2 LU/ha UAA in Belgium, Greece and the Netherlands (table 4.1). Manure production per hectare is also relatively high in these countries and exceeds 200 kg N/ha (appendix 5). It is highest in the Netherlands (346 kg N/ha). The share of pigs and poultry in total livestock population of dairy farms is relatively high in that country (15%). In Greece figures on a per hectare basis reach high values because common pastures are not included in the area of arable crops and grass. However, manure will be spread on these pastures. The disposal of manure is overestimated. Greece is therefore not presented in figure 4.1 en 4.2.

Figure 4.1 shows the impact of policy on dairy farms in the Member States. The nitrogen surplus and the amount of manure disposed under a standard on the application and under a levy on the surplus can be compared to the CAP Reform scenario. Manure disposal can be regarded as a kind of surplus. The total of the nitrogen surplus and the amount of manure disposed varies largely across the countries, whereas it remains constant under the scenarios assessed. The only exception to this is the Netherlands. There, the total of the surplus and the amount of manure disposed increases under the standard on the application. The application standard leads to increasing mineral fertilizer use to maintain crop production.

The effect of policy on the gross margin is presented in figure 4.2. The absolute change of the gross margin with respect to the CAP Reform scenario is shown. The gross margin under a levy on the surplus is rather low compared to the gross margin under the application standard.

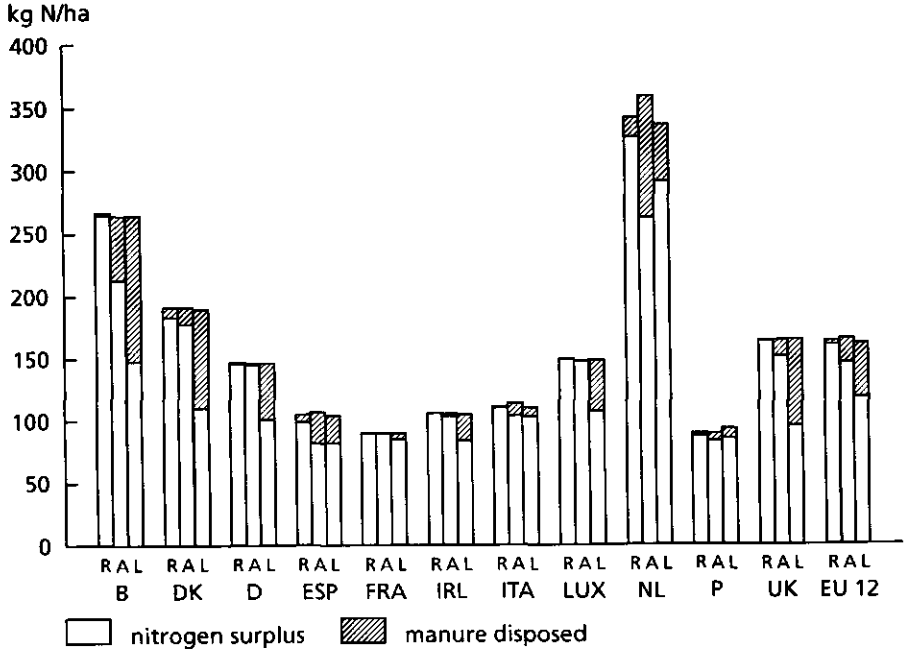

Figure 4.1 Comparison of the nitrogen surplus (kg N/ha) and the amount of manure disposed (kg N/ha) under the CAP Reform (R), under a standard on the application (A) and under a levy on the surplus (L) on dairy farms

Source: Farm Model results LEI-DLO.

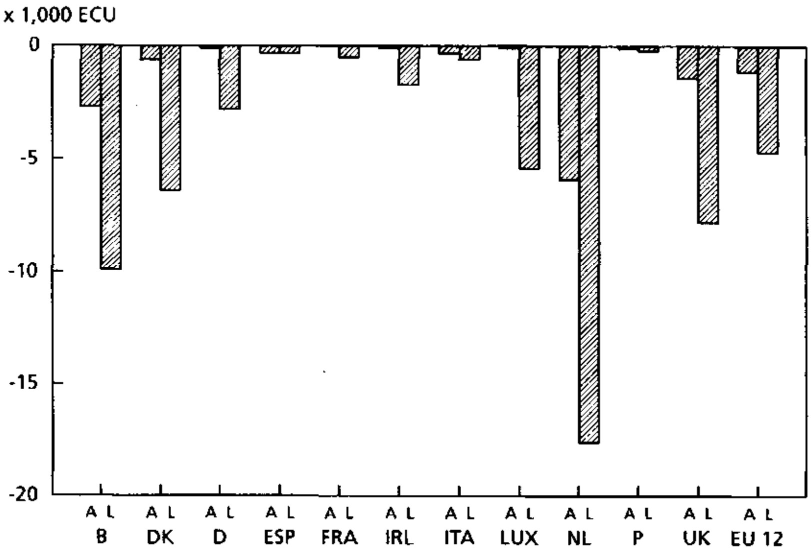

Figure 4.2 Absolute difference of the gross margin per farm (x 1,000 ECU) under a standard on the application (A) and under a levy on the surplus (L) compared to the CAP Reform on dairy farms

Source: Farm Model results LEI-DLO.

At dairy farms, CAP Reform has some impact on income. In most Member States the gross margin of dairy farms is reduced due to the reform. The decrease is largest in the Netherlands and Belgium. The decrease of the gross margin as a result of the price reduction of milk and beef exceeds the increase of the gross margin due to cheaper feed concentrates and premiums on beef and cereals, including fodder maize. CAP Reform does not change the nitrogen balance significantly. The amount of manure disposed in the base and CAP Reform scenario due to existing policy is modest in most countries. It is highest in the Netherlands (16 kg N/ha). Existing policy focuses on phosphate in this country, whereas the share of pigs and poultry in total livestock population is high. The phosphate/nitrogen-ratio of pigs and poultry manure (1:1.7 pigs for fattening, 1:1.0 breeding sows and 1:1.3 poultry) is low compared to cattle manure (1:2.8) in the Netherlands. This means that in case pigs and poultry manure is applied under a phosphate standard only relatively small amounts of nitrogen can be applied compared to cattle manure.

Table 4.2 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in the European Union

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	46.4	45.6	44.5	40.9
Nitrogen surplus	157	160	146	118
Deposition	21	21	21	21
Manure production	178	181	179	180
Purchase of fertilizer	105	106	109	105
Uptake by crops	109	109	109	108
Manure disposed	3	3	19	43

Source: Farm Model results LEI-DLO.

The application standard forces farms to reduce manure production or to dispose manure. The level of the disposal costs assessed does not reduce the manure production per hectare drastically. Table 4.2 shows that in EU 12 on average about 16 kg N/ha has to be disposed of in addition under the application standard. It is even higher in Belgium, Spain and the Netherlands (figure 4.1). Animal density is relatively high in these countries (table 4.1). Consequently the gross margin is reduced by 1,100 ECU per farm on average in EU 12. If there are sufficient minerals to meet crop requirements, manure can be disposed without additional purchase of mineral fertilizer. This is not the case in the Netherlands, about 27 kg of nitrogen fertilizer has to be purchased in addition per hectare to replace the nitrogen in organic manure disposed. More minerals enter the farm to replace minerals leaving the farm.

A levy on the surplus can be avoided by disposal of organic manure. Table 4.2 shows that on average about 40 kg of nitrogen per hectare is disposed in addition. The gross margin is reduced 4,700 ECU per farm on average. Manure disposal does not only discard nitrogen but also phosphate and potassium. If total costs of disposal plus costs for additional purchases of mineral fertilizer exceed the costs of the levy, it is cheaper to pay the levy. This is the case in the Netherlands. Only the amount of manure not needed for crop requirement is disposed.

Under a levy on the surplus, the surplus is lowest although the gross margin is lowest as well in all Member States. The only exception to this is the Netherlands. The surplus is lowest and the gross margin is highest under the application standard in this country. In the Netherlands the organic requirement of the crop is relatively high, and subsequently only the amount of manure not needed for crop requirement is disposed under a levy on the nitrogen surplus. The disposal of organic manure under the application standard exceeds the disposal under the levy in this country. In all Member States it is the other way round. In the Netherlands a levy on the nitrogen surplus does not meet the application standard on organic manure of 170 kg of nitrogen per hectare. The gross margin of dairy farms in countries, which purchase considerable amounts of fertilizer, like Belgium and the Netherlands, is much more affected by a levy on the surplus than by the application standard. The application standard meets standards on forehand by forcing farms to dispose manure and does not burden mineral fertilizer purchases, like the levy on the surplus does. In countries like Germany, France, Ireland and Luxembourg the application standard has hardly any consequences contrary to the levy on the nitrogen surplus. The level of the 'levy free zone' is important in this respect.

4.3 Impact at different levels of manure production

Supply of animal manure in EU 12 exceeds 170 kg of nitrogen per hectare (excluding 20% emission losses) on approximately 19% of the number of dairy holdings represented by FADN. This is the equivalent of almost 115 thousand holdings. The number of farms affected by the application standard varies considerably among the Member States (figure 4.3). The share of the number of dairy farms with excess of nitrogen from animal manure in total number of dairy farms is lowest in Germany, France, Ireland and Luxembourg (less than 5%) and highest in the Netherlands (97%). Within the Member State there are also differences among the regions in the share of dairy farms which meet policy requirements already.

A more detailed assessment of the impact of policy is made in Denmark, the Netherlands and in some regions with considerably higher nitrogen surpluses than the national averages. Nordrhein-Westfalen, Bretagne, Lombardia and England West are selected. Three groups of farms are distinguished for each region: farms with lowest manure production per hectare (low), with highest manure production per hectare (high) and the category in between (medium). Of each category, 24 randomly chosen dairy farms are individual optimized, since the sample contains only a limited number of farms. Farm structure characteristics of weighted averages of the farms selected are presented by region for the categories distinguished in table 4.3. The gross margin

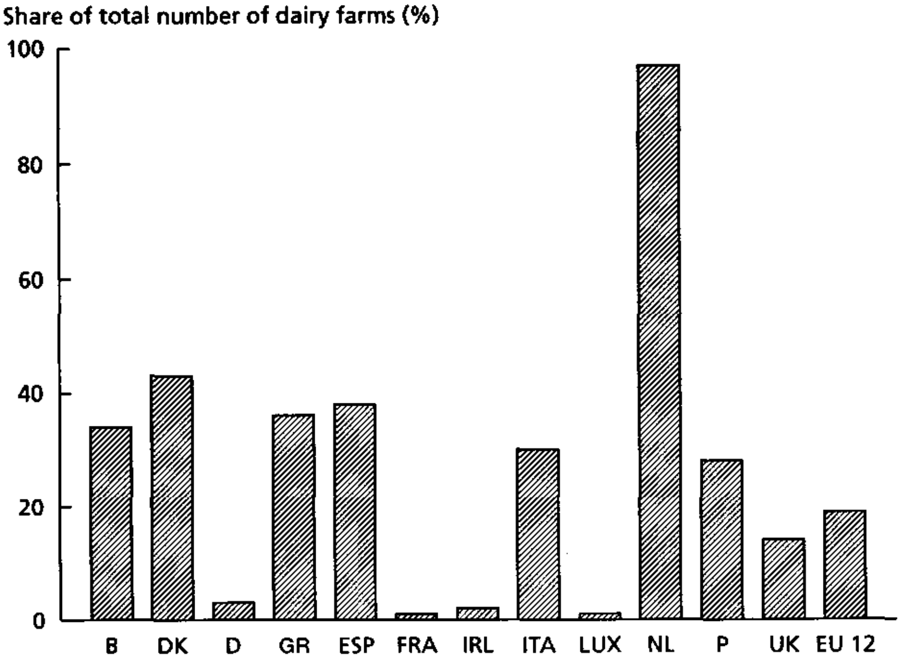

Figure 4.3 Share of total number of dairy farms (%) with production levels of animal manure exceeding 170 kg of nitrogen per hectare (excluding emission losses) in 1990/91
Source: FADN-CCE-DG VI/A-3; adaptation LEI-DLO.

and nitrogen balances of these groups of farms under the scenarios assessed are presented in appendix 6. The impact of policy on the nitrogen surplus and the amount of manure disposed in the categories distinguished are shown in figure 4.4.

Livestock density in the category 'high' is about double that of category 'low' in the countries and regions selected (table 4.3). In Bretagne livestock density is rather low and shows a limited variation among the groups of farms considered, compared to other countries and regions. Contrary to this is Lombardia, where livestock density as well as livestock composition does differ considerably among the groups of farms with the highest and the group with the lowest manure production per hectare. The share of pigs and poultry in total livestock population is rather low and does not show major variation across the groups of farms considered in the regions. There are two exceptions to this. The share of pigs and poultry in the category 'high' is 41% in the Netherlands and 8% in Bretagne. In Denmark UAA shows major variation across the groups of farms. Farms in the category 'high' have only 19 ha of land.

Table 4.3 Farm structure of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on dairy farms in a number of regions

Country/region	Category	Utilized agricultural area (ha)	Livestock density (LU/ha)	of which dairy cows (%)	of which pigs & poultry (%)
Denmark	low	47	1.4	58	2
	medium	37	1.8	60	3
	high	19	3.2	61	4
Nordrhein-Westfalen	low	36	1.2	60	2
	medium	39	1.5	56	3
	high	35	2.2	59	2
Bretagne	low	30	1.0	67	0
	medium	24	1.3	66	2
	high	25	1.8	58	8
Lombardia	low	21	0.5	30	0
	medium	19	2.3	49	1
	high	16	4.9	65	2
Netherlands	low	31	2.0	65	1
	medium	29	2.6	65	4
	high	25	4.7	40	41
England West	low	68	1.3	60	0
	medium	65	1.9	62	0
	high	46	2.5	61	5

Source: Farm Model results LEI-DLO.

Nitrogen surpluses of dairy farms within regions show rather diverse patterns. In Lombardia the surplus in the base situation in the category 'high' is about tenfold that of category 'low' (table A6.4). Livestock density is also about tenfold (table 4.3). Differences between both categories are about 100 kg of nitrogen surplus in Denmark, Nordrhein-Westfalen, the Netherlands and England West. In Bretagne the nitrogen surplus shows limited variation among the groups of farms. The scenarios assessed in Bretagne have hardly any impact, except the levy on the surplus in the category 'high' (figure 4.4). Most farms meet already the requirements of policy.

The application standard has hardly any impact on farms in the categories 'low' and 'medium' in Denmark, Nordrhein-Westfalen and England West (figure 4.4). These farms already meet the application standard. However, these farms are affected by a levy on the surplus. In the Netherlands the application standard forces farms in all categories to dispose so much manure that supplementary purchases of mineral fertilizer are needed to maintain crop production (table A6.5). In the category 'medium' and 'high' in Lombardia additional fertilizer purchases take place as well (table A6.4). Other forage crops, which have a rather high organic requirement, have a relatively high share in the cropping plan of these farms. Additional fertilizer has to be purchased, since organic manure application does not meet this requirement. The total of nitrogen sur-

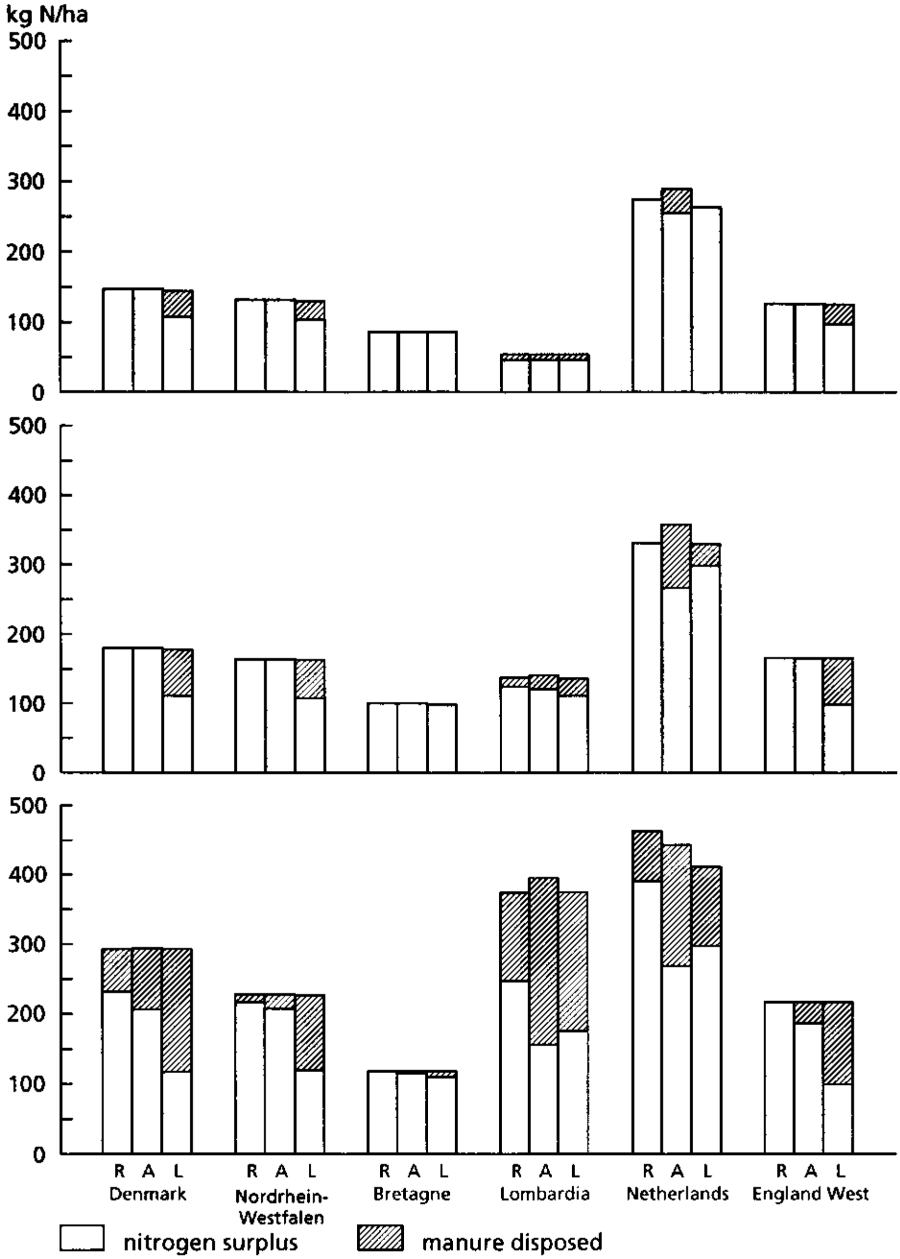

Figure 4.4 Comparison of the nitrogen surplus (kg N/ha) and the amount of manure disposed (kg N/ha) in the categories 'low' (L), 'medium' (M) and 'high' (H) under the CAP Reform (R), under a standard on the application (A) and under a levy on the surplus (L) on dairy farms

Source: Farm Model results LEI-DLO.

plus and manure disposed is therefore higher under the application standard compared to the CAP Reform scenario in these categories (figure 4.4). The only exception to this is category 'high' in the Netherlands, because manure production is reduced under strict environmental policy from 494 kg N/ha to 431 kg N/ha (table A6.5). Livestock density is reduced from 4.7 LU/ha to 4.2 LU/ha. This extensification effect is due to the low gross margin of pigs per unit of nitrogen. Farms in the category 'low' in Lombardia meet policy requirements of both scenarios already.

The gross margin under the levy on the nitrogen surplus is rather low compared to the gross margin under the application standard in most categories (appendix 6), especially in the Netherlands. The gross margin is about 15% lower under the levy than under the application standard, due to the high amounts of fertilizer purchased in all categories in this country.

4.4 Concluding remarks

1. Differences among Member States and regions are large on the number of dairy farms that produce more than 170 kg of nitrogen per hectare (excluding emission losses). Supply of animal manure exceeds this level at 19% of the dairy holdings in EU 12. The share of dairy farms with excess of nitrogen from organic manure is highest in the Netherlands (97%) and lowest in Germany, France, Ireland and Luxembourg (less than 5%). These shares hardly change under the application standard scenario, since the impact of the standard on the production of organic manure is modest.
2. The application standard reduces the nitrogen surplus by 14 kg per hectare on average, whereas the levy reduces it by 42 kg per hectare in EU 12. The levy on the nitrogen surplus meets the application standard at all dairy farms, except at intensive dairy farms. Mainly at dairy farms with high fertilizer purchases the choice of the policy instrument is important.
3. Amounts of manure disposed are calculated per hectare. The average size of dairy farms is 28 ha in EU 12. Whereas 13% of the total number of farms in EU 12 are dairy farms. This means that about 317 million kilograms of nitrogen has to be disposed at dairy farms in EU 12 under the application standard.
4. The results of the model show that the organic manure application standard of 170 kg of nitrogen per hectare leads to increasing mineral fertilizer use to maintain crop production at intensive farms in the Netherlands, which is contradictory to policy in this country. It is likely that the use of mineral fertilizer will not increase, because of a higher degree of utilization of animal manure, by application during the period of crop growth. Besides, minerals are used abundantly. The use of minerals can be reduced without reducing crop production per hectare. Further, extensification of crop production due to a lower input use of minerals is also possible. However, these adjustments are not considered in the framework of the model. Under the levy on the surplus additional purchases are not needed.

5. The gross margin of dairy farms is reduced by 1,100 ECU per farm on average under the application standard and by 4,700 ECU under the levy on the surplus in EU 12. It varies largely among the farms.

5. NITROGEN BALANCE OF GRANIVORE FARMS

5.1 Introduction

Granivore farms are characterized by the fact that the production of manure per hectare is considerable, which is mainly due to the high livestock density and subsequent the high purchases of feed concentrates. A large share of manure produced at granivore farms has to be applied outside the farm. The impact of policy on nitrogen balances is presented for granivore farms in this chapter. The balances are based on national weighted averages of 40 randomly chosen individual optimized granivore farms under the scenarios assessed. An exception to this is Greece, since the sample of granivore farms contains less than 40 farms in that country. Results of Ireland and Luxembourg are not presented. The size of the FADN sample of granivore farms is less than fifteen farms in these countries. Section 5.3 provides insight into the number of granivore farms affected by the application standard. A more detailed assessment of the impact of policy is made for Bretagne. It is examined whether groups of granivore farms in Bretagne already meet the requirements of policy. Farm structure characteristics will be presented. Some concluding remarks are presented in section 5.4.

5.2 Impact of the policy instruments

The farm structure of the weighted average of the granivore farms selected is presented by Member State in table 5.1. The gross margin and nitrogen balances of these farms under the scenarios assessed are presented by Member State in appendix 7. The effects of policy on the nitrogen surplus and the amount of manure disposed are presented by Member State in figure 5.1. The change of the gross margin compared to the CAP Reform scenario is shown in figure 5.2. The weighted average gross margin and nitrogen balance of all selected individual optimized granivore farms in ten Member States are presented in table 5.2.

Table 5.1 Farm structure of granivore farms in the Member States

Country	Utilized agricultural area (ha)	Livestock density (LU/ha)	of which pigs (%)	of which poultry (%)
Belgium	5	43.9	77	22
Denmark	31	6.9	93	7
Germany	15	5.1	94	5
Greece	1	86.9	66	34
Spain	5	24.1	65	35
France	22	12.5	56	40
Italy	8	58.9	36	64
Netherlands	4	58.1	61	37
Portugal	6	11.3	76	22
United Kingdom	12	31.7	64	31
EU 12	10	19.8	64	35

Note: EU 12 excludes Ireland and Luxembourg.
Source: Farm Model results LEI-DLO.

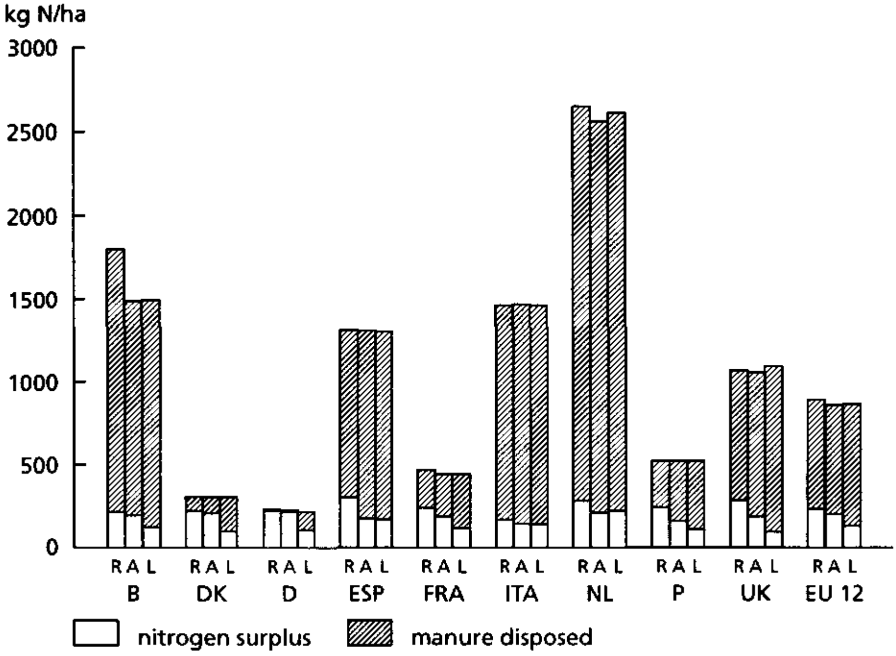

Figure 5.1 Comparison of the nitrogen surplus (kg N/ha) and the amount of manure disposed (kg N/ha) under the CAP Reform (R), under a standard on the application (A) and under a levy on the surplus (L) on granivore farms
Note: EU 12 excludes Ireland and Luxembourg.
Source: Farm Model results LEI-DLO.

The relatively small size of utilized agricultural area per farm, and the high livestock population are major determinants of the high rates of mineral surpluses at granivore farms compared to that of dairy farms presented before. UAA is below 6 ha in Belgium, Greece, Spain and the Netherlands. It is relatively high in Denmark, Germany and France (table 5.1). Livestock density of granivore farms exceeds 40 LU/ha UAA in Belgium, Greece, Italy and the Netherlands. Manure production exceeds 1,800 kg of nitrogen per hectare in these countries (appendix 7). The share of poultry in total livestock population of granivore farms is less than 10% in Denmark and Germany. Whereas, in Italy almost two third of the total livestock population at granivore farms is comprised of poultry.

The total of the nitrogen surplus and the amount of manure disposed varies largely across the countries (figure 5.1). It remains constant under the scenarios assessed, except in Belgium and the Netherlands. The amount of manure disposed per hectare does not increase substantially, whereas the gross margin is reduced considerably in most countries (figure 5.2).

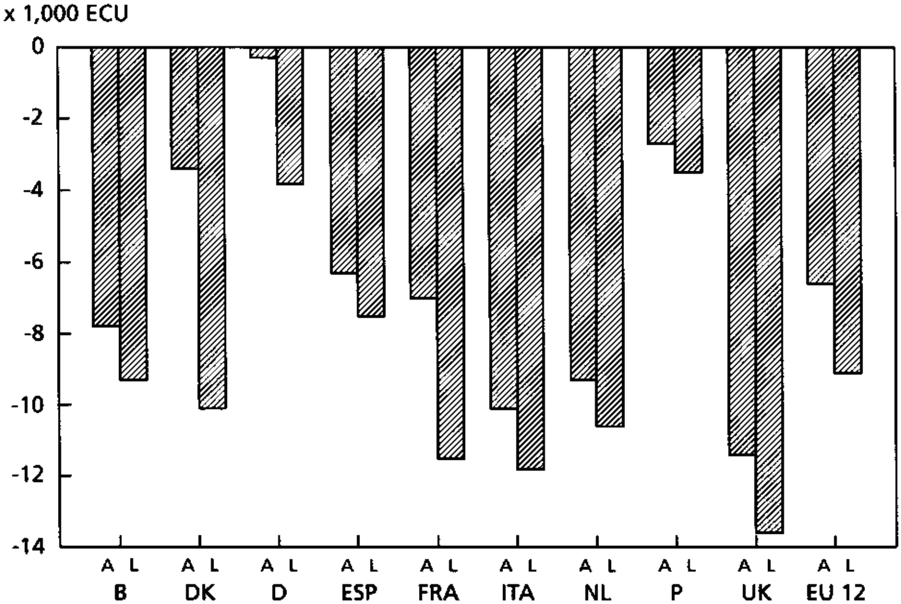

Figure 5.2 Absolute difference of the gross margin per farm (x 1,000 ECU) under a standard on the application (A) and under a levy on the surplus (L) compared to the CAP Reform on granivore farms

Note: EU 12 excludes Ireland and Luxembourg.

Source: Farm Model results LEI-DLO.

CAP Reform reduces the gross margin of granivore farms in Belgium, the Netherlands and the United Kingdom substantially. The gross margin will decrease in case the price advantage of feed concentrates does not compensate the lower output prices. The price change of feed concentrates in a country (table 2.3) depends on the share of European grown cereals in feed concentrates. If the share is relatively low, like in the Netherlands, the price reduction of feed concentrates is relatively small. In the base and CAP Reform scenario substantial amounts of manure are already disposed due to existing policy, which in some Member States focuses mainly on phosphate (figure 5.1).

Table 5.2 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in the European Union

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	94.6	92.9	86.3	83.8
Nitrogen surplus	233	240	206	135
Deposition	24	24	24	24
Manure production	1,035	1,074	1,030	1,046
Purchase of fertilizer	114	117	120	114
Uptake by crops	105	106	105	105
Manure disposed	628	654	657	735

Note: EU 12 excludes Ireland and Luxembourg.
Source: Farm Model results LEI-DLO.

Under the application standard the amount of manure disposed at granivore farms does not change drastically on average (table 5.2). However, it increases somewhat in most Member States due to a strict environmental policy and decreases in Belgium and in the Netherlands as a result of lower manure production per hectare (appendix 7). In these countries the level of disposal costs assessed reduces the livestock density. In Belgium, livestock density is even reduced by almost 5 LU per hectare because of the low gross margin of poultry per unit of nitrogen. The gross margin is reduced by 6,600 ECU per farm on average (table 5.2). It varies largely among the countries and is in the range between 300 ECU per farm in Germany and about 11,000 ECU in the United Kingdom (figure 5.2). Total disposal costs per farm depend not only on the amount of manure disposed per hectare but also on the number of hectares per farm.

Under a levy on the surplus more organic manure is disposed compared to the application standard (table 5.2). The surplus is on average reduced by some 100 kg N/ha. The amount of organic manure disposed depends on the organic requirement of the crops in the Member States. Organic manure not necessary for crop requirement is disposed. The gross margin is reduced by 9,100 ECU per farm on average. It varies largely among the countries (figure 5.2).

The lower gross margin under strict policy, compared to the CAP Reform scenario, is mainly due to the higher level of disposal costs assumed. Under the application standard it is also partly the result of the decrease in the number of livestock units like in Belgium and of additional fertilizer purchases like in the Netherlands. The decrease of the gross margin under the levy on the surplus is partly the result of the higher amount of manure disposed and the payment of the levy on that part of the surplus, which exceeds 100 kg per hectare.

The difference between the gross margin under the application standard and under the levy is highest in Denmark (6,700 ECU). In this country 108 kg N/ha is disposed in addition under the levy compared to the application standard, whereas the average area of the farm is 31 ha.

The levy on the nitrogen surplus is more strict than the application standard and reduces the application of organic manure to a level even below the 170 kg N/ha limit. Under the application standard the gross margin is higher although the surplus is also higher in most countries. However, in the Netherlands the surplus is lowest and the gross margin is highest under the application standard. The levy does not meet the application standard in this country. The aimed reduction in organic manure application is not achieved, the levy is paid. In case both inputs are burdened (like under the levy) and the crop requirement is high, manure containing minerals needed for crop requirement is not disposed to avoid additional fertilizer purchases. Consequently the organic application limit is not met by the levy on the nitrogen surplus.

5.3 Impact at different levels of manure production

Supply of animal manure in EU 12 exceeds 170 kg of nitrogen per hectare (excluding 20% emission losses) on approximately 87% of the number of granivore holdings represented by FADN. This is the equivalent of almost 53 thousand holdings. The number of farms affected by the application standard varies among the Member States (figure 5.3). The share of the number of granivore farms with excess of nitrogen from animal manure in total number of granivore farms is lowest in Germany (53%) and Denmark (73%). It exceeds 80% in the other Member States and it is even 100% in Belgium, Greece and in the Netherlands. Most farms do not meet the requirements of the application standard.

In Bretagne three groups of granivore farms are classified according to the production level of animal manure per hectare. Of each category, 24 randomly chosen granivore farms are individual optimized, since the sample contains only a limited number of farms.

Livestock density in the category 'high' is about fivefold that of category 'low' in Bretagne (table 5.3). UAA in the category 'high' is relatively small (12 ha) compared to UAA in the category 'low' (35 ha). The share of poultry in total livestock population ranges between 7% (category 'low') and 32% (category 'high').

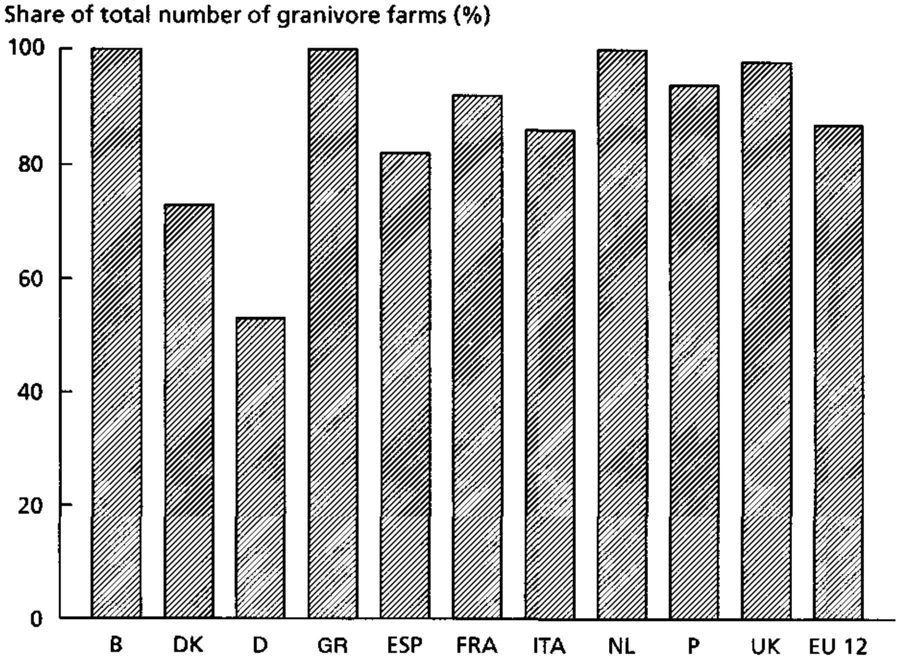

Figure 5.3 Share of total number of granivore farms (%) with production levels of animal manure exceeding 170 kg of nitrogen per hectare (excluding emission losses) in 1990/91
Source: FADN-CCE-DG VI/A-3; adaptation LEI-DLO.

Table 5.3 Farm structure of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on granivore farms in Bretagne

Country	Category	Utilized agricultural area (ha)	Livestock density (LU/ha)	Of which pigs (%)	Of which poultry (%)
Bretagne	low	35	5.0	90	7
	medium	23	9.1	85	11
	high	12	24.3	67	32

Source: Farm Model results LEI-DLO.

The manure production at granivore farms in Bretagne in the category 'high' is also about fivefold that of category 'low', it ranges between 220 kg N/ha and 1,100 kg N/ha (table 5.4). In the CAP Reform situation in the category 'low' 5 kg N/ha, at 'medium' 94 kg N/ha and at 'high' 651 kg N/ha are disposed. Under strict policy the amount of manure which has to be disposed in addition increases with rising manure production per hectare.

Table 5.4 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on granivore farms in Bretagne

	Low				Medium				High			
	Base	CAP Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	79	73	72	65	87	87	82	76	111	107	97	94
Nitrogen surplus	200	220	212	107	266	272	221	111	260	262	212	106
Deposition	17	17	17	17	17	17	17	17	17	17	17	17
Manure production	219	220	218	195	384	394	395	387	1,082	1,090	1,146	1,143
Purchase of fertilizer	112	127	129	119	135	139	140	134	117	120	122	117
Uptake by crop	95	95	96	91	106	106	106	104	96	96	96	94
Manure disposed	9	5	12	94	86	94	146	245	644	651	747	848

Source: Farm Model results LEI-DLO.

5.4 Concluding remarks

1. Differences among Member States and regions are large on the number of granivore farms that produce more than 170 kg of nitrogen per hectare (excluding emission losses). Supply of animal manure exceeds this level at 87% of the granivore holdings in EU 12. The share of granivore farms with excess of nitrogen from organic manure is lowest in Germany (53%) and Denmark (73%). It exceeds 80% in the other Member States. Manure production per hectare is high due to the high livestock density at granivore farms.
2. The amount of manure disposed at granivore farms under the application standard does not change drastically on average. More is disposed under a levy on the nitrogen surplus compared to the application standard. The levy on the nitrogen surplus meets the application standard in almost all Member States.
3. The average size of granivore farms is 10 ha in the ten Member States assessed. Whereas only 1.4% of the total number of farms in EU 12 are granivore farms. This means that the total amount of manure disposed at granivore farms in response to strict policy is modest. Granivore farms were already affected by existing environmental policy.
4. The livestock density will decrease in Belgium and to a lesser extent in the Netherlands in response to strict environmental policy because of the low gross margin of poultry per unit of nitrogen. Livestock density will be reduced in case the marginal gross margin of an extra livestock unit per hectare is negative. It will mainly decrease in response to a prohibitive levy.
5. The gross margin of granivore farms is reduced by 6,600 ECU per farm on average under the application standard and by 9,100 ECU per farm under the levy on the surplus in the ten Member States assessed. It differs among the farms. The lower gross margin is mainly the result of the higher level of disposal costs assumed under strict policy.

6. NITROGEN BALANCE OF CEREAL FARMS

6.1 Introduction

At cereal farms organic manure input originates mainly from outside the farm. Farms are not affected by strict policy in terms of disposal of organic manure but they can purchase organic manure against lower costs. Costs of purchase of organic manure are assumed to be higher in the base and CAP Reform scenario than under the application standard and a levy on surplus. Under more stringent environmental policy measures more manure has to be disposed. Therefore it is assumed that under the application standard and a levy on the surplus organic manure can be applied at cereal farms for free (section 3.2). The impact of policy on nitrogen balances is presented for cereal farms in this chapter. The balances are based on national weighted averages of 40 randomly chosen individual optimized cereal farms under the scenarios assessed. An exception to this is Ireland, since the sample of cereal farms contains less than 40 farms in that country. Results of Belgium, Luxembourg and the Netherlands are not presented. The size of the sample is less than fifteen cereal farms in these countries. In Belgium and the Netherlands considerable amounts of organic manure have to disposed. General cropping farms and horticultural holdings are suppliers of disposal room as well. Some concluding remarks are presented in section 6.3.

6.2 Impact of the policy instruments

The farm structure of the weighted average of the cereal farms selected is presented by Member State in table 6.1. The gross margin and nitrogen balances of these farms under the scenarios assessed are presented by Member State in appendix 8. The change of the gross margin compared to the CAP Reform scenario is shown in figure 6.1. The weighted average gross margin and nitrogen balance of all selected cereal farms in nine Member States are presented in table 6.2.

Utilized agricultural area per farm is in the range between 15 ha (Greece and Italy) and 122 ha (United Kingdom). The share of oil seeds in total UAA exceeds 10% at cereal farms in Denmark, Germany and France (table 6.1). The share of pulses is highest in France (9%).

Table 6.1 Farm structure of cereal farms in the Member States

Country	Utilized agricultural area (ha)	of which cereals (%)	of which oil seeds (%)	of which pulses (%)
Denmark	24	83	10	1
Germany	28	77	11	0
Greece	15	94	1	0
Spain	48	79	5	1
France	69	72	14	9
Ireland	32	74	0	1
Italy	15	85	1	0
Portugal	38	57	3	0
United Kingdom	122	67	7	3
EU 12	39	72	6	2

Note: EU 12 excludes Belgium, Luxembourg and the Netherlands.
Source: Farm Model results LEI-DLO.

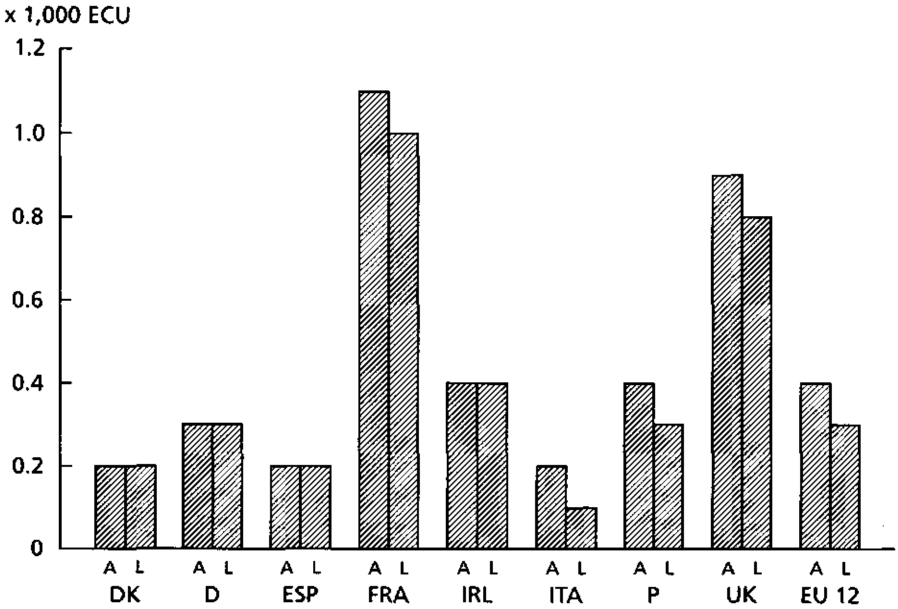

Figure 6.1 Absolute difference of the gross margin per farm (x 1,000 ECU) under a standard on the application (A) and under a levy on the surplus (L) compared to the CAP Reform on cereal farms
Note: EU 12 excludes Belgium, Luxembourg and the Netherlands.
Source: Farm Model results LEI-DLO.

Table 6.2 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in the European Union

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	19.7	19.6	20.0	19.9
Nitrogen surplus	38	35	53	51
Deposition	13	13	13	13
Manure production	6	6	6	6
Purchase of fertilizer	96	95	77	79
Purchase of organic manure	0	0	43	39
Uptake by crops	76	76	76	76

Note: EU 12 excludes Belgium, Luxembourg and the Netherlands.
Source: Farm Model results LEI-DLO.

Table 6.2 shows a small decrease of the gross margin under the reform as a result of the price reduction of cereals. The decrease is largest in the United Kingdom (table A8.9). In the United Kingdom more than 65% of farms with cereals produce more than 92 tonnes of cereals, oil seeds and protein crops and have to comply with set-aside requirements in order to receive compensation payments on a per hectare basis (Venema et al., 1995). The gross margin increases in Spain and Portugal (table A8.4 and A8.8). In Portugal most farms are small-scale producers. In Spain, on the other hand, large areas were under fallow before the reform. The set-aside requirements in this country do not reduce production substantially. No organic manure is purchased in the base and CAP Reform scenario due to the assumed relatively high purchase costs of organic manure compared to inorganic fertilizer. However, presently in some countries cereal farms purchase organic manure already.

Under the application standard as well as under the levy on the nitrogen surplus there is supply of disposal room at cereal farms. On average about 43 kg N/ha can be purchased under the application standard and 39 kg N/ha under the levy (table 6.2). It ranges between 15 kg N/ha in Spain and about 60 kg N/ha in France (appendix 8).The area of cereals in France, however, covers approximately 31% of total area of cereals in EU 12 (Venema et al., 1995). The gross margin increases by 400 ECU per farm on average, since less mineral fertilizer has to be purchased. The increase is almost equal under both scenarios and is largest in France and the United Kingdom (figure 6.1).

The surplus is higher under both environmental policy scenarios assessed compared to the CAP Reform situation because organic manure contributes more to the surplus than fertilizer. This explains also the somewhat higher surplus under the application standard, more organic manure is purchased under the application standard compared to the levy. At some farms the purchase of organic manure is restricted by the levy on the nitrogen surplus. However, the application standard is not a constraint and at most of the farms the 'levy free zone' of the levy on the nitrogen surplus is still not exceeded. The use of organic manure can be increased further. The impact of a further replacement of mineral fertilizer by organic manure is shown in section 7.3. In the absence of a 'levy free zone', no organic manure will be purchased at cereal farms.

6.3 Concluding remarks

1. Cereal farms are not affected by strict environmental policy in terms of disposal of organic manure but they can purchase organic manure against lower costs. Purchases of organic manure instead of mineral fertilizer will increase the nitrogen surplus.
2. On average about 43 kg N/ha can be purchased under the application standard and 39 kg N/ha under the levy. The choice of the policy instrument is not important with respect to the total purchases of organic manure but towards the total supply by disposal at other farming types and consequently towards the level of the costs of purchases.
3. The average cereal farm size is 39 ha in the nine Member States assessed, which means that the supply of disposal room is considerable (1,600 kg of nitrogen per farm on average). However, 7.2% of the total number of farms in EU 12 are cereal farms. In total considerable amounts of manure can be purchased at cereal farms. Total supply of disposal room will be even higher considering the potential purchases at general cropping and horticultural farms.
4. At most of the cereal farms the increased use of organic manure does not lead to problems to meet standards of environmental policy. The use of organic manure can be increased further.
5. The gross margin of cereal farms increases by 400 ECU per farm on average in the nine Member States assessed, since less mineral fertilizer has to be purchased.

7. ADJUSTMENTS IN FARMING PRACTICE

7.1 Introduction

Farmers might respond to agri-environmental policy measures by introducing adjustments in farming practice like the use of special feed concentrates containing lower amounts of protein, which reduce mineral excretion levels. Another possibility is more replacement of mineral fertilizer by organic manure, which becomes relatively cheaper under strict environmental policy. Emission-reducing techniques can be introduced to lose less minerals during storage and spreading. Other technological progress like processing of manure and manure separation are also important in this respect. The latter increases the dry-matter content of manure. This is an option to limit costs of transport over long distance. An overall introduction of adjustments leads to a decrease of the local disposal pressure and of the original incentives.

Options available to reduce losses of minerals to the environment arise from various stages (figure 7.1). At the input side by a more efficient use of feed (1), in the production process by replacement of mineral fertilizers by organic manure (2) and by less emission losses during storage and spreading (3).

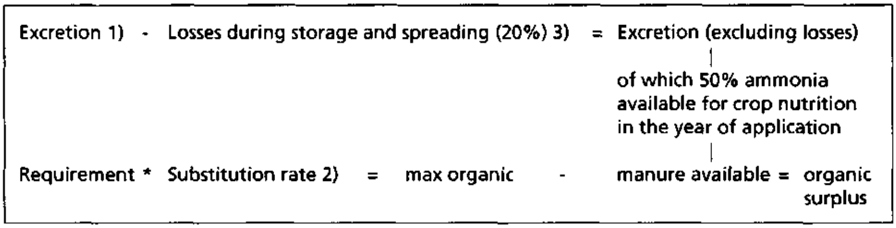

Figure 7.1 Options to reduce losses of nitrogen to the environment arise from various stages
Source: LEI-DLO.

The assessment of these adjustments is based on the hypothesis that management aspects regarding the treatment of minerals at farm level may largely affect the potential for leaching. The effects of these three adjustments are presented separately in sections 7.2 to 7.4.

7.2 Improved composition of feed concentrates

The improvement of the amino acid balance of the diet can bring about a better adaptation of protein. This option reduces nitrogen pollution at its source of production. Feed nitrogen is better utilized. The costs of such a preventive approach to pollution control are modest. Mineral production can be reduced without substantially increasing the cost of primary feed ingredients (Dourmad et al., 1995). Besides an improved protein balance there are also improved feeding programs. The reduction in N and P excretion and increase in feedcosts based on improved Dutch feed composition are presented in table 7.1. Other feed compositions are possible as well. Knowledge available of feed composition in other Member States is rather limited. The Dutch situation is used for the other countries.

Table 7.1 Percentage change in annual N and P excretion per animal and in the feedcosts under improved feed composition of -10% N and -10% P in the Netherlands in 1991

	N excretion (%)	P excretion (%)	Feedcosts (%)
Pigs for fattening	-21	-23	2.4
Sows	-5	-21	1.9
Laying hens	-18	-15	5.4
Slaughter chickens	-12	-2	3.0

Source: Baltussen, 1992.

The improved composition of feed concentrates can reduce the mineral content in animal manure. However, low levels of minerals are not preferable for transportation over long distance. Purchasers of organic manure prefer organic manure with a high concentration of minerals. Mainly on granivore farms, it is an interesting option to reduce nitrogen pollution at its source of production. As mineral levels in animal manure are reduced, less manure has to be disposed, more tonnes of organic manure can be applied at the farm under the nitrogen application standard. When the reduction in the disposal costs exceeds the increase in feedcosts, improved feed concentrates will be introduced. The gross margin increases, since the amount of manure disposed decreases. The introduction of improved feed concentrates is mainly an interesting option at farms which face high disposal costs and under a prohibitive levy on the surplus.

The overall introduction of improved feed concentrates will reduce the total amount of manure disposed in the region. The pressure on the manure market will diminish. It will create better disposal possibilities against lower costs. Farms that did not introduce the improved feed concentrates will gain from this overall effect, they are free riders.

In order to monitor the progress achieved by other feed compositions, records of inflow and outflow components of mineral balances at farm level are required. The content of minerals in feed concentrates as well as in animal manure has to be registered.

Nitrogen production is reduced by about 14% in Belgium (table 7.2) and the Netherlands (table 7.3) as a results of a reduction of nitrogen in feed concentrates by 10% (table 7.1). The livestock composition is rather stable. Under both scenarios disposal costs are reduced. The gross margin increases by respectively 400 and 800 ECU in spite of the increased feedcosts.

Table 7.2 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in Belgium with-and-without improved feed composition

Improved feed composition	Application standard		Levy on surplus	
	no	yes	no	yes
Gross margin	104.7	105.1	103.2	103.6
Nitrogen surplus	198	199	127	125
Deposition	33	33	33	33
Manure production	1,771	1,523	1,783	1,541
Purchase of fertilizer	134	135	133	134
Uptake by crops	99	99	98	98
Manure disposed	1,287	1,090	1,367	1,177

Source: Farm Model results LEI-DLO.

Table 7.3 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in the Netherlands with-and-without improved feed composition

Improved feed composition	Application standard		Levy on surplus	
	no	yes	no	yes
Gross margin	95.7	96.5	94.8	95.7
Nitrogen surplus	216	205	229	216
Deposition	36	36	36	36
Manure production	3,137	2,700	3,224	2,706
Purchase of fertilizer	173	184	157	169
Uptake by crops	157	157	156	157
Manure disposed	2,345	2,017	2,385	1,995

Source: Farm Model results LEI-DLO.

7.3 Replacement of mineral fertilizer by organic manure

The use of fertilizers may change in response to more strict regulation on the treatment and application of organic fertilizers. The increasing supply of organic manure under strict policy makes organic manure more competitive compared to mineral fertilizer and creates disposal room. For example in the

Netherlands the use of organic manure at arable farms presently shows an increasing trend at the expense of inorganic fertilizers. In 1989/90 the use of organic manure is 3,721 kg of nitrogen per arable farm, which is about 83 kg N/ha in this country. It is 91 kg N/ha in 1990/91 and about 97 kg N/ha in 1991/92 (Poppe et al., 1994a). In 1992/93 it is even about 100 kg N/ha (Poppe et al., 1994b). The use of mineral fertilizer decreased from 162 kg N/ha in 1989/90 to 142 kg N/ha in 1992/93.

The replacement of mineral fertilizer by organic manure depends on the rate of substitution, the maximum amount of nitrogen from organic manure per kilogram of total nitrogen requirement of crops. Substitution rates used in the analysis so far are considered to reflect farmers' behaviour regarding the treatment of animal manure around the year 1990, which is subject to change over time. When the rate is based on what is technically feasible instead of on actual farmers' behaviour, substitution by organic manure can be extended. In the assessments made a substitution rate of 25% is assumed for those crops with a substitution rate of actual farming practice less than 25%. Substitution rates are presented in appendix 3 (table A3.3). Even a rate of 37.5% is assessed to show the sensitivity of this parameter.

Cereal farms are assessed because mainly on arable crops a substantial replacement in the use of mineral fertilizer by animal manure is possible. Substitution takes place in case the costs of purchase and application of organic manure are lower than purchase and application costs of mineral fertilizer, for the same quantity of available minerals. It is assumed in the analysis that the purchase of organic manure is much cheaper than the purchase of mineral fertilizer under strict environmental policy. Substitution of mineral fertilizer by organic manure therefore increases the gross margin of the arable sector.

Under the application standard the purchase of organic manure increases while the purchase of fertilizer decreases under the 25% and 37.5% substitution rates at cereal farms in France and the United Kingdom (table 7.4 and 7.5).

Table 7.4 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in France with actual and technical substitution rates

Substitution rate	Application standard			Levy on surplus		
	actual	25%	37.5%	actual	25%	37.5%
Gross margin	43.8	44.4	45.1	43.7	44.3	44.7
Nitrogen surplus	70	87	107	69	86	97
Deposition	19	19	19	19	19	19
Manure production	2	2	2	2	2	2
Purchase of fertilizer	113	98	82	114	100	91
Purchase of organic manure	61	101	145	59	96	121
Uptake by crops	110	110	110	110	110	110

Source: Farm Model results LEI-DLO.

Table 7.5 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in United Kingdom with actual and technical substitution rates

Substitution rate	Application standard			Levy on surplus		
	actual	25%	37.5%	actual	25%	37.5%
Gross margin	66.1	67.0	67.8	66.0	66.7	67.3
Nitrogen surplus	61	74	90	60	73	83
Deposition	18	18	18	18	18	18
Manure production	8	8	8	8	8	8
Purchase of fertilizer	94	82	69	93	82	75
Purchase of organic manure	39	70	106	38	68	89
Uptake by crops	88	88	88	88	88	88

Source: Farm Model results LEI-DLO.

The increase in purchases of organic manure is about 2.5 times the decrease in the purchase of fertilizer, because only 40% of the nitrogen of the purchased organic manure is available for crop nutrition in the year of application. The amounts of organic manure applied are below the restricted quantity of the application standard. The application standard is still not a constraint.

Under a levy on the surplus the purchase of organic manure is restricted. Substitution contributes to a higher surplus. The levy on the surplus is a constraint. Fertilizer is substituted by organic manure up to the level of the 'levy free zone' of 100 kg of nitrogen surplus per hectare. Above this level the costs of the levy exceed the save on expenses of substitution.

7.4 Emission reduction

Ammonia policy in Belgium and the Netherlands stresses measures to stimulate more efficient use of nitrogen. Like, for example in the manure and ammonia policy in the Netherlands (LNV, 1995). Changes take place in the way animal manure is applied. In several Member States animal manure presently is injected immediately or worked under the ground soon after application. This implies that the emissions are reduced compared to application practice in the past. Losses during storage can be reduced by stable adjustments and sealing of manure storage facilities. Nitrogen losses during storage and spreading are assumed to be about 20% of total nitrogen from manure production in the analysis so far. Of the remaining nitrogen 50% is ammonia, which is available for crop nutrition in the year of application (Schleef and Kleinhanss, 1994). Only 40% of nitrogen in organic manure is available to the crop in the year of application. As losses are assumed to be reduced to only 5% of total nitrogen from manure production, 47.5% is available to the crop in the year of application. More minerals remain in the manure, which makes manure more acceptable for arable farms and for transportation.

Losses during storage and spreading are excluded from the nitrogen surplus calculated here. In the short term fewer losses increase the nitrogen surplus and more minerals have to be disposed to meet policy requirements (table 7.6 and 7.7). Although in the long term deposition will be reduced as well and the surplus will probably not change. However, in the assessments made only the short term effect is considered. This means that under the application standard and a levy on the surplus the gross margin declines at lower emission losses, since the amount of manure disposed inclines. Furthermore, investment in sealing of manure storage facilities and more expensive manure application techniques are needed. In the results presented the costs of these investments have not been taken into account.

Table 7.6 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Belgium with-and-without emission reduction

Emmission losses	Application standard		Levy on surplus	
	20%	5%	20%	5%
Gross margin	48.8	47.0	41.9	39.3
Nitrogen surplus	213	218	148	172
Deposition	33	33	33	33
Manure production	269	269	269	268
Purchase of fertilizer	194	194	193	194
Uptake by crops	178	178	178	178
Manure disposed	51	86	116	131

Source: Farm Model results LEI-DLO.

Table 7.7 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in the Netherlands with-and-without emission reduction

Emmission losses	Application standard		Levy on surplus	
	20%	5%	20%	5%
Gross margin	79.5	76.6	67.8	65.0
Nitrogen surplus	262	276	291	306
Deposition	36	36	36	36
Manure production	332	326	341	329
Purchase of fertilizer	246	259	216	214
Uptake by crops	189	189	189	189
Manure disposed	97	140	45	67

Source: Farm Model results LEI-DLO.

7.5 Concluding remarks

Farmers might respond to agri-environmental policy measures by introducing adjustments in farming practise. The impact of a more efficient use of feed concentrates, substitution of inorganic fertilizer by organic manure and emission reduction are analysed separately.

1. Improved feed concentrates reduce the nitrogen content in animal manure. It is an interesting option at granivore farms, which face high disposal costs. Under the application standard more tonnes of organic manure, containing lower levels of nitrogen, can be applied at the farm and consequently less tonnes have to be disposed. The gross margin will increase in spite of the higher feed costs. An overall introduction leads to a decrease of the local disposal pressure. Introduction is only meaningful in case the progress achieved is monitored by an administration system.
2. Replacement of inorganic fertilizer by organic manure may increase at arable farms as organic manure becomes cheaper as a result of the increasing demand for disposal room under strict policy. When the rate of substitution is based on what is technically feasible instead of on actual farming practice, substitution by organic manure can be extended. It decreases the purchase of fertilizer and increases the purchase of manure, which raises the surplus and decreases the gross margin. At a higher rate of substitution, the replacement is restricted by the levy on the surplus. The application standard is not a constraint.
3. Losses of minerals to the atmosphere can be reduced by emission-reducing techniques. Investments in manure storage facilities and more expensive application techniques are needed. Fewer losses increase the surplus in the short term. More minerals have to be disposed to meet policy requirements and subsequently income will decrease. However, in the long term deposition will be reduced as well and the surplus will probably not change.

8. CONCLUDING REMARKS

8.1 Introduction

Some of the findings on the assessment of the impact of environmental policy on mineral balances at farm level in the European Union are summarized in this chapter. A distinction is made between considerations concerning the results (section 8.2) and the methodology used (section 8.3). Finally some recommendations are given (section 8.4).

8.2 Impact at farm level

Lessons learned

Although the development and implementation of an integrated economic/environmental farm model at an European level is still in its infancy, and faces some limitations, a number of important issues have arisen from this attempt.

- Differences among Member States and regions are large on the number of farms that produce more than 170 kg of nitrogen per hectare (excluding emission losses) from livestock manure. Supply of animal manure exceeds this level at 19% of the dairy holdings and 87% of the granivore holdings, whereas cereal farms do not exceed this level in EU 12.
- The increasing pressure on the manure market due to strict environmental policy is mainly the result of the increase in the total amount of manure disposed at dairy farms and to a lesser extent at granivore farms. Granivore farms were already affected by existing environmental policy, which focused mainly on phosphate in some countries. The application standard has hardly any further impact on granivore farms in terms of flows of organic manure. At cereal farms less mineral fertilizer will be purchased since considerable amounts of organic manure could be obtained at lower costs. At most cereal farms the increased use of manure does not lead to problems to meet standards on the application of livestock manure.
- When production is intensive, the application standard of 170 kg of nitrogen from organic manure per hectare is lower than the organic requirement of the crop. Additional usage of mineral fertilizer is needed to maintain crop production and to replace the minerals in organic manure disposed. This does not consider any improvement in utilization of livestock manure. However, it might be the case that additional purchases of fertilizer are not needed because of a higher degree of utilization of animal manure. Besides minerals are often used abundantly, it is possible

to reduce the use of minerals without reducing the production per hectare. In addition crop production is very intensive, the use of minerals can be reduced at the expense of crop production per hectare.

- A better distribution of organic manure among the farms by exchanging surplus manure from one farm to another will decrease the income of disposers of organic manure (mainly dairy and granivore farms affected by the policy), whereas purchasers (arable farms) will gain. Granivore farms may gain by the use of feed concentrates with a better digestion of proteins. It will only be introduced in case the reduction in the disposal costs exceeds the increase in feed costs. When the rate of substitution is based on what is technically feasible instead of on actual farming practice, substitution by organic manure can be extended and the gross margin of arable farms will increase further. The change of the gross margin in this report is a reflection of the impact of policy in terms of exchanges of manure between farms, whereas there will be a range of adjustment possibilities. However, other adjustments instead of those flows in manure bear costs as well.

Aggregated results

The results of this approach must of course be interpreted with the necessary care and are certainly not saying anything about the macro-economic effects of environmental policy. This requires a sectoral approach considering all farming types. Besides only a limited set of adjustment processes is considered. In addition the identification of the policies proposed is a determining factor for the outcome of the model. Nevertheless, the obtained results show which farms are affected most and show the direction of manure transfers between farms.

In Belgium and the Netherlands the demand for disposal room is considerable. Although there are no cereal farms (suppliers of disposal room) assessed in both countries. This does not mean that there are no farms which can purchase organic manure. General cropping farms are potential purchasers of organic manure as well. This farming type covers a total area of about 300 thousand hectare in Belgium and of about 573 thousand hectare in the Netherlands. Manure production at general cropping farms is 55 kg N/ha in Belgium and 11 kg N/ha in the Netherlands (Brouwer et al., 1995).

The allocation of organic manure under strict environmental policy towards farms with low density of animal population is only presented by the inflow and outflow of minerals at the farm. In the EU 12 dairy farms cover a total area of about 16.7 million hectares, while it was calculated that there is an excess of organic manure of around 20 kg N/ha under the application standard. Granivore farms cover about 0.7 million hectares, while the excess of organic manure is 650 kg N/ha under the application standard. Cereal farms cover 12.5 million hectares of land and can purchase some 40 kg N/ha. In total only 535 million kg of nitrogen can be purchased at cereal farms, while the total amount of excess manure at dairy and granivore farms is even more. Organic manure can be transferred to general cropping farms and other farming types, like vineyards as well. General cropping farms cover 24.7 million hectares of land and the average manure production at these farm is oround 20 kg N/ha.

In most Member States allocation of organic manure among farms under stricter policy seems possible, especially when potential purchases are considered. However, within the countries animal production can be concentrated in some regions, like in Bretagne, whereas arable production can be concentrated in others, like in the Northern cereal area of France. Transportation of organic manure between such regions is not always likely, because of the distance between the regions and the associated costs. In case the regional supply exceeds the usage substantially the level of disposal costs will increase further and consequently manure production will be reduced in the region. However, only a modest reduction in livestock density is presented by the model results, because disposal costs are determined exogenously and do not depend on the pressure on the manure market in the region.

8.3 Methodology used

Reflection on the method used

Linear-Programming models can consider a number of alternatives simultaneously. This advantage is exploited for assessing CAP Reform. For the evaluation of the impact of different environmental policy instruments a number of on-farm adjustments have to be taken into consideration and therefore farm LP-models are one of the main tools to be available. However, this advantage of LP-models is not reflected in the results shown in this report, since mainly changes of nitrogen flows in response to changes of policy are made. Whereas the optimization considers also possible adjustments in livestock population and crop production in response to changes in agricultural and environmental policies. The model results show only occasionally any of these adjustments. It shows for example a decrease in livestock density at granivore farms in Belgium and the Netherlands. A higher level of disposal costs would have shown more of this kind of adjustments.

Assumptions made

In the model a number of assumptions are made, with respect to the adaptation possibilities and the disposal costs, which have to be considered by the interpretation of the results. These assumptions are determining for the robustness of the approach.

First, effects should be considered in the context of limited adaptation possibilities. A kind of worst-case scenario is assessed. Focus is mainly limited to nitrogen flows as a result of policy changes. Farms are assumed to be unable to increase the proportion of their land they can spread manure on. Besides the modelled farms are not allowed to switch to other production activities. The adjustments in livestock composition and cropping plan are limited, whereas extensification of crop production is restricted as well. However generally spoken, one may expect a trend towards extensification of production. The allocation of livestock production may change in the EU towards farms with low livestock density and a surplus of feed. Besides, the allocation of land may change towards farms with high surpluses.

Second, the level of disposal costs is exogenously determined and is not differentiated by Member State. However in general, the disposal costs farmers face is determined by the occurrence of other manure suppliers and demanders in the region and the adaptation behaviour of other farms to policy. In case the regional supply exceeds the usage substantially the level of disposal costs will increase further and consequently manure production will be reduced in the region, given that processing of animal manure and disposal towards other regions do not take place at large scale. Insight into the development of the costs of disposal, determined by manure market interactions, in the region under strict policy so far is rather limited. The level of the disposal costs is a determining factor for the introduction of adjustment processes like feed concentrates with a low crude protein level. There exists a trade-off between the reduction in disposal costs and costs of feeding measures. At a higher level of disposal costs this adjustment becomes more attractive to introduce.

Further the level of disposal costs, which is expressed per kg of nitrogen, is assumed to increase under strict environmental policy in the analysis made. In most countries the amount of manure which has to be disposed increases substantially with a stricter policy and the assumed increase in the level of disposal costs is justified. However, in some regions the increase in the total amount of manure disposed is limited. Disposal costs will not increase in case strict policy has hardly any impact.

In addition the assumed costs to obtain organic manure in the base and CAP Reform scenario and the assumed free gains of organic manure under strict policy are also not justified in all cases. First, in the base and CAP Reform scenario cereal farms received organic manure already for free in some cases. Second, in some regions the increased supply of manure will be limited under strict policy and purchases of organic manure still have to be paid. Third, the costs of application of organic manure in relation to the costs of fertilizer application are important as well. Fourthly, the purchase price of organic manure depends not only on the supply of organic manure but on the quality of the manure, the mineral contents and the nitrogen/phosphate ratio as well. The manure market is segmented, it distinguishes manure of different composition.

Policy instruments

It is clear that the impact of policy measures on nitrogen balances depends on the level of mineral fertilizer and/or organic manure used. A standard on the application of organic manure and a levy on the nitrogen surplus are both assessed at farm level. The application standard does not burden mineral fertilizer contrary to the levy on the surplus. Besides under the levy on the surplus disposal is not compulsory, only manure not needed for crop requirement will be disposed. Another scenario not assessed could have been a levy on fertilizer (Becker and Kleinhanss, 1995). The model would have shown that a reduction in fertilizer use (as a result of a levy on fertilizer) and consequently an increase in manure use leads to an increase in the surplus.

The levy on the surplus, like assessed here, includes a 'levy free zone' of 100 kg of nitrogen surplus per hectare. This zone is derived from the limit to identify regions vulnerable for nitrate leaching. The relationship between a surplus level of 100 kg N per hectare and leaching of nitrates is not direct and may largely depend on site-specific conditions (e.g. climate and soils). A levy on the surplus is a more strict limit for pollution reduction than the application standard. Nitrogen surplus under the application standard is higher than in the case of a levy on the surpluses exceeding 100 kg of nitrogen surplus per hectare. Supplementary fertilizer policy is needed under the application standard to approach the achieved reduction of the surplus, under a levy on the nitrogen surplus. Both scenarios are not in line with each other, comparison has to be made with the necessary care.

It is also hard to formulate different environmental policy instruments which meet similar environmental targets. Other disciplines so far did not succeed in defining one allowable surplus level which meets the European Legislation leaching limit of 50 mg/litre placed on the levels of nitrate allowable in drinking water. The leaching of minerals from the soil to ground water depends on a range of biophysical factors. The importance of other disciplines in this kind of environmental research cannot be over-emphasized.

For a levy on the surplus to be an efficient instrument, the level of the levy has to be tuned to the disposal costs or in other words to the pressure on the manure market. If the levy is relatively high compared to the disposal costs, there is a tendency to dispose considerable amounts of organic manure to avoid the levy. If the levy is relatively low it has no environmental consequences at all, only the levy is paid. The level of disposal costs, the level of the levy and the level of the 'levy free zone' have a significant impact on the model results. In this respect it is noteworthy that other levels would have generated different outcomes.

Interpretation of policy

For the choice of a policy instrument it is important that the objectives of the Nitrate Directive will be achieved. The Nitrate Directive focuses not only on the application standard of organic manure of 170 kg of nitrogen per hectare, like assessed in one of the scenarios. A number of elements of the Nitrate Directive can be distinguished, which need to be outlined further. First, the use of mineral fertilizers is an essential part of the Nitrate Directive, as the directive considers the use of mineral fertilizer in the codes of good agricultural practises. It depends on the interpretation of these codes in the Member States, whether the use of inorganic fertilizer will be restricted. Second, the standard on the application of animal manure of 170 kg of nitrogen per hectare, in zones identified to be vulnerable to the leaching of nitrate, should be met at farm level by the year 2003 at the latest unless the goals formulated in the Directive could be achieved through other instruments. For the first four year action programme (1996-1999) Member States may allow an amount of manure containing up to 210 kg of nitrogen per hectare. Third, the Nitrate Directive (Council Directive 91/676/EEC, Annex III, point 2, sub b) offers during and after the first four-year action programme, Member States possibilities to fix different application amounts from those referred to above. These amounts must be fixed so as not to prejudice the achievement of the objectives of the directive and must be justified on the basis of objective criteria e.g. long growing seasons, crops with high nitrogen uptake, high net precipitation in the vulnerable zone and soils with exceptionally high denitrification capacity. If a Member State allows a different amount, it shall inform the Commission which will examine the justification. Finally, only zones identified to be vulnerable to the leaching of nitrate need to meet the requirements of policy instead of the whole territory.

It is important to distinguish between excess of manure according to prevailing standards on application of manure and mineral surpluses. In the calculation of the mineral surpluses in the present report an abstraction is made for manure transfers between farms. Soilless farming types can achieve low mineral surpluses in case excess of manure is disposed. Whereas, arable farms can have mineral surpluses but normally have little excess of manure. In case manure is transferred, it is more conform the 'Polluter Pays Principle' to burden farms which apply organic manure abundantly instead of the farms which produce organic manure.

Data available across the European Union

The application of mineral fertilizers is not recorded at crop level. A normative approach is used to assess application of minerals. The requirement of mineral fertilizer per crop is derived from crop yields observed, the total expenditures on fertilizer purchases at the farm and the amount of minerals provided by organic manure. Although mineral fertilizer requirements used here reflect total expenditures on fertilizer purchases at the farm, the distribution of these expenditures among the minerals and crops is still an estimate.

Comparison to other results

The assessments available in the European Union of the impact of environmental policy on mineral surplus at farm level are rather limited so far. A consistent comparison of results from other sources is difficult. Not only because of other assumptions made and methodologies used but also because of differences in the interpretation of policies. A limited set of results on the impact of policy is available for the Netherlands. A recent effort in this country for example asessed the socio-economic impact of alternative policies to reduce nitrogen and phosphate surpluses (Nieuwenhuize et al., 1995). This analysis was based on the consideration of a broad set of options available to farmers in meeting these standards on the losses to the environment. Whereas, the base and CAP Reform situation can be compared to earlier work of the project. Differences will be briefly commented upon in the following paragraphs.

The nitrogen balance in the base situation calculated with the LP-model can be compared to the nitrogen balance in the report: 'Mineral balances at farm level in the European Union' (Brouwer et al., 1995). FADN data of the same base year have been used for the calculation of both balances. However, the base situation in the present report is optimized. The average farm structure characteristics of the farms assessed here can be compared to those of the total sample considered in Brouwer et al. (1995). There are no substantial differences observed, which indicates that the sample assessed here is representative. Differences in nitrogen surpluses arise because for the purpose of the present research the nitrogen surplus excludes the amount of manure disposed in the optimized base situation. Mainly at granivore farms substantial amounts of manure are disposed in the base situation due to existing environmental policy. The amount of manure disposed can also be considered as a kind of surplus. The nitrogen surplus of cereal farms is comparable in most Member States, although purchases of fertilizer and uptake by crops show not always similar values. Surpluses of dairy and granivore farms calculated with the LP-model are higher because 20% instead of 30% (Brouwer et al., 1995) emission losses are assumed. Differences in manure production are mainly due to the nitrogen contents of dairy manure, which depends on the milk yield in the present report. Besides results of Belgium are different, the excretion figures of the Netherlands have been used for Belgium.

There are already accounting data of manure disposal available in the Netherlands. In 1993/94 dairy farms disposed on average 453 kg of nitrogen per farm, which is 16 kg of nitrogen disposed per hectare (Poppe et al., 1995, table B.3). The present report shows an equal figure for disposal under existing environmental policy, which validates the CAP Reform scenario of dairy farms (table A5.10). According to Poppe et al. (1995) granivore farms disposed on average 9,103 kg of nitrogen per farm. The results of the assessments made in the present report show an average disposal in the CAP Reform scenario of around 2,400 kg of nitrogen per hectare at granivore farms (table A7.8). Since, granivore farms in the Netherlands cover on average an area of about 4 hectares the results are similar.

The impact of CAP Reform on mineral balances can be compared to the outcome of the assessment at regional (Becker and Kleinhanss, 1995) and national level (Hellegers, 1995). It was concluded at regional and national level that the impact of CAP Reform on nitrogen surpluses is modest. This is in line with the farm level results.

Outlook to the achievements made

The assessments made are derived from an optimization procedure of individual farms. The optimization of individual farms is based on the consideration of possible adjustments in livestock population and crop production in response to changes in agricultural and environmental policies. In addition, farmers could respond to such policies in terms of adjusting input and output flows of nitrogen, mainly from organic sources.

The adjustment processes considered in this report are rather limited and certainly do not intend to reflect dynamic processes of individual farmers. They merely aim to address changes of nitrogen flows in response to changes of policy. More detailed investigations allowing for dynamic responses by farms would have been very resource consuming, require major additional sources of information and knowledge on technical-economic relationships in the various regions and farming types investigated. Strict environmental policy will also generate new techniques in agriculture, which is not taken into account in this report.

It is quite ambitious to model the impact of different policy instrument at farm level in the EU and to assess processes of change in the agricultural sector in response to these instruments. Not only because of the problems faced to incorporate dynamic processes like described above. It is also hard to formulate different environmental policy instruments which meet similar environmental targets. Besides it is crucial to have knowledge on how the national government will interpret common environmental policies.

8.4 Recommendations

Recommendation 1

There will be a range of adjustments in farming practice instead of only nitrogen flows. These dynamic adjustment processes of individual farmers have to be taken into consideration in the future development of these types of models.

Recommendation 2

It is recommended for further research to determine the disposal costs endogenously in the model, by manure market interactions instead of exogenously. More knowledge is needed about suppliers of disposal room at horticulture farms and adjustment processes at the farm.

Recommendation 3

It is recommended to register production and treatment of animal manure in the Farm Accountancy Data Network (FADN) of the European Commission. This will provide information on the way how animal manure is being treated at farm level. Such a registration would be required in zones vulnerable to leaching of nitrates to monitor progress achieved by the agricultural sector in meeting the objectives of the Nitrate Directive. Besides it is recommended to register usage of mineral fertilizers at crop level. This work may build upon the experience from the Farm Accountancy Data Network in the Netherlands and their expertise to keep records of inflow and outflow components of mineral balances at farm level.

Recommendation 4

The Farm Accountancy Data Network (FADN) of the European Commission should also register whether a farm of the sample is located in a zone identified to be vulnerable to leaching of nitrates from agriculture, according to the response to the European Commission by Member States to the Nitrate Directive.

Recommendation 5

The farm model can, although its limitations, also be used for other research. It is especially suitable to quantify the impact of policies at farm level.

It can for example be used to assess the impact of agricultural and environmental policies (mainly with regard to minerals) for different regions in a rather consistent manner.

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LIST OF SYMBOLS AND ABBREVIATIONS

.	No data available or sample less than 15 farms
CAP	Common Agricultural Policy
CEC	Commission of the European Communities
DG-XII	Directorate General for Science, Research and Development of the CEC
EC	European Communities
ECU	European Currency Unit
EEC	European Economic Community
EU	European Union
EUROSTAT	Statistical Office of the European Communities
FADN	Farm Accountancy Data Network
FAL	Bundesforschungsanstalt für Landwirtschaft (Federal Agricultural Research Centre), Institut für Betriebswirtschaft (Institute of Farm Economics), Braunschweig, Germany
INRA	Institut National de la Recherche Agronomique, Rennes, France
LEI-DLO	Landbouw-Economisch Instituut (Agricultural Economics Research Institute), The Hague, the Netherlands
LEI-IEA	Landbouw-Economisch Instituut, Brussels, Belgium
LP	Linear-Programming
LU	Livestock Unit
N	Nitrogen
P_2O_5	Phosphate
REGIO	Regional Data Bank of Eurostat
SJI	Statens Jordbrugsøkonomiske Institut (Institute of Agricultural Economics), Copenhagen, Denmark
SPEL	Sectoral Production and Income model for agriculture
STI	Economics Department of the University of Stirling, Stirling (Scotland), United Kingdom
UAA	Utilized Agricultural Area

APPENDICES

Appendix 1 Activities distinguished

Animals:

dairy cows
suckler cows
female calves
male calves
breeding heifers
heifers for fattening
bulls for fattening
piglets
breeding sows
pigs for fattening
breeding pigs
table chickens
laying hens
ewes
goats

Crops:

soft wheat
durum wheat
rye
barley
oats
grain maize
other cereals (includes rice)
sugar beet
potatoes
rape seed
sunflower
other oil seeds (including soya beans)
dry pulses
maize for silage
forage on arable (excludes maize for silage)
permanent grass
fallow

Appendix 2 Coefficients used to convert species and classes of livestock to Livestock Units

Class or species		Number of livestock units per animal (LU)
Cattle:	calves for fattening	0.4
	other cattle < 1 year	0.4
	male cattle 1 - <2 years	0.6
	female cattle 1 -<2 years	0.6
	male cattle >= 2 years	1.0
	breeding heifers	0.5
	heifers for fattening	0.5
	dairy cows	1.0
	cull dairy cows	1.0
	other cows	0.8
Pigs:	piglets	0.027
	breeding sows	0.5
	pigs for fattening	0.3
	other pigs	0.3
Poultry:	table chickens	0.007
	laying hens	0.014
	other poultry	0.03
Sheep:	ewes	0.1
	other sheep	0.1
Goats:	goats, breeding females	0.1
	other goats	0.1
Other animals:	equines	0.6

Source: CEC, 1989:70; personal additional information CEC.

Appendix 3 Coefficients used in the calculation of the nitrogen balances

Table A3.1 Nitrogen supply from organic manure in kg N/animal/year by species and country

Animal	Country				
	Germany United Kingdom Ireland	France Italy Greece Spain Portugal	Denmark	Luxem-bourg	Belgium Nether-lands
Dairy cows	60+10*yld	60+10*yld	60+10*yld	60+10*yld	60+10*yld
Calves	15	17.3	38.3	26.4	25.4
Male cattle 1-<2 year	50	50.4	43.8	61.6	78
Female cattle 1-<2 year	50	50.4	38.3	61.6	78
Male cattle >=2 year	85	59.1	43.8	88	100
Breeding heifers	85	67.2	38.3	88	100
Heifers for fattening	85	59.1	38.3	88	100
Other cows	85	58.7	73.3	88	120
Sheep	7	8.1	15	7.5	21.8
Goats	7	8.1	15	7.5	15
Breeding sows	29	39.7	30.9	27.5	35
Pigs for fattening	11	10.1	14.5	11.8	13.9
Other pigs	18.3	20.1	22.9	17.2	17.2
Poultry	0.5	0.6	0.66	0.6	0.58
Equines	68.6	67.2	50	88	45

Note: yld = milkyield in 1,000 kg of milk produced.

Note:
- Figures of Germany are used for the United Kingdom and Ireland.
- Figures of France are used for Italy, Greece, Spain and Portugal.
- Figures of the Netherlands are used for Belgium.

Note: Figures are based on the figures used by Brouwer et al. (1995).
There are two exceptions to this:
- figures of the Netherlands are used for Belgium;
- excretion levels of dairy cows depend on the milk yield.

Table A3.2 Nitrogen requirement of crops in kg N/ha

Crop	Country		
	Germany United Kingdom Ireland Belgium Luxembourg Denmark	France Italy Portugal Spain Greece	Netherlands
Wheat	10 + 25 * yld	24 * yld	167
Barley	20 + 20 * yld	19 * yld	108
Grain maize	40 + 20 * yld	40 + 20 * yld	40 + 20 * yld
Other cereals	20 + 20 * yld	20 * yld	108
Potatoes	40 + 4 * yld	4.4 * yld	333
Sugar beet	80 + 2 * yld	2.3 * yld	268
Rape seed	60 + 50 * yld	60 + 50 * yld	125
Sunflower	5 + 40 * yld	5 + 40 * yld	-
Grass a)	-30 + 24 * yld	-30 + 24 * yld	-30 + 24 * yld
Fodder - crops b)	-30 + 24 * yld	-30 + 24 * yld	-30 + 24 * yld
- maize c)	30 + 3.2 * yld	30 + 3.2 * yld	30 + 3.2 * yld

a) Excludes rough grazing; b) Temporary grass and fodder roots and brassicas; c) Fodder maize and other forage plants.
Note: yld = yield of the crop in tonne per hectare.
Source: Schleef and Kleinhanss, 1994.

Table A3.3 Maximum kg N from organic manure per kilogram total N requirement of crops

Crop	Country					
	Germany, United Kingdom, Ireland, Belgium, Luxembourg, Denmark		France, Italy, Portugal, Spain, Greece		Netherlands	
	actual farmers behaviour	assumed to be technically feasible	actual farmers behaviour	assumed to be technically feasible	actual farmers behaviour	assumed to be technically feasible
Wheat	0.15	0.25	0.15	0.25	0.00	0.25
Barley	0.15	0.25	0.15	0.25	0.00	0.25
Grain maize	0.20	0.25	0.80	0.80	0.00	0.25
Other cereals	0.15	0.25	0.15	0.25	0.00	0.25
Potatoes	0.20	0.25	0.20	0.25	0.50	0.50
Sugar beet	0.20	0.25	0.20	0.25	0.60	0.60
Rape seed	0.20	0.25	0.20	0.25	0.00	0.25
Sunflower	0.00	0.25	0.00	0.25	-	-
Grass a)	0.20	0.25	0.50	0.50	0.50	0.50
Fodder - crops b)	0.20	0.25	0.50	0.50	0.50	0.50
- maize c)	0.30	0.30	0.80	0.80	0.50	0.50

a) Excludes rough grazing; b) Temporary grass and fodder roots and brassicas; c) Fodder maize and other forage plants.

Table A3.4 Nitrogen uptake of crops in kg N/ha

Crop	Country		
	Germany United Kingdom Ireland Belgium Luxembourg Denmark	France Italy Portugal Spain Greece	Netherlands
Wheat	20 * yld	19 * yld	22.2 * yld
Barley	17 * yld	15 * yld	18.5 * yld
Grain Maize	14 * yld	15 * yld	15 * yld
Other cereals	16 * yld	16 * yld	16.3 * yld
Potatoes	3.2 * yld	3.5 * yld	3.6 * yld
Sugar beet	1.8 * yld	1.8 * yld	1.5 * yld
Rape seed	33 * yld	35 * yld	33.3 * yld
Sunflower	30 * yld	19 * yld	-
Grass a)	17 * yld	17 * yld	17 * yld
Fodder - crops b)	17 * yld	17 * yld	17 * yld
- maize c)	3 * yld	3.1 * yld	3.1 * yld

a) Excludes rough grazing; b) Temporary grass and fodder roots and brassicas; c) Fodder maize and other forage plants.
Note: yld = yield of the crop in tonne per hectare.
Source: Schleef and Kleinhanss, 1994.

Appendix 4 Calculation of the nitrogen balance

The nitrogen surplus presented in table A4.1 (row 2) excludes the amount of manure disposed (row 7) and includes (80% of) the amount of manure purchased in the case of cereal farms. The nitrogen surplus is defined as the deposition from the atmosphere (row 3), production of manure (row 4) and total supply of nitrogen from inorganic fertilizer (row 5), reduced by the uptake of harvested crops (row 6) and nitrogen losses to the atmosphere (20% of row 4). Nitrogen surplus as defined here is; row 3 + 0.8*row 4 + row 5 - row 6 - row 7;
36 + 0.8*346 + 219 - 189 - 18 = 324.8 ~325, which is equal to row 2.

Table A4.1 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in the Netherlands

	A Base	B CAP Reform	C Application standard	D Levy on surplus
1 Gross margin	89.5	85.4	79.5	67.8
2 Nitrogen surplus	325	326	262	291
3 Deposition	36	36	36	36
4 Manure production	346	346	332	341
5 Purchase of fertilizer	219	219	246	216
6 Uptake by crops	189	189	189	189
7 Manure disposed	18	16	97	45

Source: Farm Model results LEI-DLO.

The higher amount of manure disposed in column C compared to B is a result of the standard on the application of organic manure of 170 kg N/ha. Part of the manure production is lost during storage and spreading. These are assumed to be 20%. Of the remaining 80% of nitrogen from manure production (0.8*332) only 170 kg N/ha can be applied. Disposal is about 96 kg N/ha, which is almost equal to row 7 of column C.

The lower gross margin in column C compared to B is the result of the higher amount of manure disposed and of the higher level of disposal costs assumed. In column B 16 kg N/ha has to be disposed for 1 ECU per kilogram, whereas in column C 97 kg N/ha has to be disposed for 2 ECU per kilogram. This means that under the application standard 97 kg N/ha *2 ECU/kg N *28 ha minus 16 kg N/ha *1 ECU/kg N *28 ha is about 5,000 ECU per farm has to be paid in addition for disposal. The gross margin is also reduced due to a lower livestock density.

The decrease of the gross margin in column D compared to B is not only the result of the higher amount of manure disposed and the higher level of disposal costs assumed but also of the payment of the levy. Under the levy 45 kg N/ha *2 ECU/kg N *28 ha minus 16 kg N/ha *1 ECU/kg N *28 ha, which is about 2,000 ECU per farm, has to be paid in addition for disposal. The levy is paid on the surplus above the 'levy free zone' of 100 kg of nitrogen surplus per hectare. The costs of the levy are 191 kg N/ha *3 ECU/kg N * 28 ha, which is about 16,000 ECU per farm. In total about 18,000 ECU has to be paid in addition. The gross margin is reduced by this amount.

Appendix 5 Gross margin and nitrogen balance on dairy farms in the Member States

Table A5.1 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Belgium

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	53.3	51.5	48.8	41.9
Nitrogen surplus	270	265	213	148
Deposition	33	33	33	33
Manure production	277	272	269	269
Purchase of fertilizer	195	194	194	193
Uptake by crops	179	178	178	178
Manure disposed	1	1	51	116

Source: Farm Model results LEI-DLO.

Table A5.2 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Denmark

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	79.8	79.6	79.0	73.2
Nitrogen surplus	177	183	178	110
Deposition	18	18	18	18
Manure production	190	199	198	197
Purchase of fertilizer	162	160	160	158
Uptake by crops	150	145	145	144
Manure disposed	6	8	13	79

Source: Farm Model results LEI-DLO.

Table A5.3 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Germany

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	41.9	41.2	41.1	38.4
Nitrogen surplus	143	146	145	101
Deposition	30	30	30	30
Manure production	142	145	144	144
Purchase of fertilizer	114	114	114	114
Uptake by crops	114	114	114	114
Manure disposed	1	1	1	45

Source: Farm Model results LEI-DLO.

Table A5.4 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Greece

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	8.6	6.9	6.6	6.4
Nitrogen surplus	112	109	105	88
Deposition	8	8	8	8
Manure production	237	233	222	213
Purchase of fertilizer	34	34	34	33
Uptake by crops	46	46	46	46
Manure disposed	73	73	68	77

Source: Farm Model results LEI-DLO.

Table A5.5 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Spain

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	9.8	9.8	9.5	9.5
Nitrogen surplus	90	99	82	82
Deposition	7	7	7	7
Manure production	182	199	198	197
Purchase of fertilizer	77	74	77	73
Uptake by crops	134	135	135	135
Manure disposed	5	6	25	22

Source: Farm Model results LEI-DLO.

Table A5.6 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in France

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	46.7	46.9	46.9	46.4
Nitrogen surplus	86	90	90	85
Deposition	17	17	17	17
Manure production	117	120	120	120
Purchase of fertilizer	55	57	57	57
Uptake by crops	81	81	81	81
Manure disposed	0	0	0	5

Source: Farm Model results LEI-DLO.

Table A5.7 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Ireland

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	40.4	39.5	39.4	37.8
Nitrogen surplus	103	106	104	84
Deposition	10	10	10	10
Manure production	127	131	131	130
Purchase of fertilizer	55	55	55	55
Uptake by crops	64	63	63	63
Manure disposed	0	0	2	21

Source: Farm Model results LEI-DLO.

Table A5.8 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Italy

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	28.8	28.6	28.3	28.0
Nitrogen surplus	105	110	104	103
Deposition	18	18	18	18
Manure production	175	181	181	180
Purchase of fertilizer	49	50	53	50
Uptake by crops	102	103	103	103
Manure disposed	2	1	10	7

Source: Farm Model results LEI-DLO.

Table A5.9 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Luxembourg

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	81.9	80.6	80.5	75.2
Nitrogen surplus	147	149	148	107
Deposition	27	27	27	27
Manure production	144	146	144	143
Purchase of fertilizer	132	135	135	134
Uptake by crops	127	129	128	128
Manure disposed	0	0	0	41

Source: Farm Model results LEI-DLO.

Table A5.10 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in the Netherlands

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	89.5	85.4	79.5	67.8
Nitrogen surplus	325	326	262	291
Deposition	36	36	36	36
Manure production	346	346	332	341
Purchase of fertilizer	219	219	246	216
Uptake by crops	189	189	189	189
Manure disposed	18	16	97	45

Source: Farm Model results LEI-DLO.

Table A5.11 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in Portugal

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	11.2	11.4	11.3	11.2
Nitrogen surplus	88	87	83	85
Deposition	4	4	4	4
Manure production	149	147	145	152
Purchase of fertilizer	37	36	36	37
Uptake by crops	70	68	67	70
Manure disposed	2	2	6	8

Source: Farm Model results LEI-DLO.

Table A5.12 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on dairy farms in the United Kingdom

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	79.6	79.5	78.1	71.7
Nitrogen surplus	161	163	151	95
Deposition	18	18	18	18
Manure production	184	186	186	186
Purchase of fertilizer	83	83	83	83
Uptake by crops	86	86	86	86
Manure disposed	0	0	13	69

Source: Farm Model results LEI-DLO.

Appendix 6 Gross margin and nitrogen balance on dairy farms in a number of regions

Table A6.1 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on dairy farms in Denmark

	Low				Medium				High			
	Base	Cap Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	88	90	90	86	85	85	85	79	74	72	70	66
Nitrogen surplus	139	147	147	107	178	181	181	112	232	232	207	117
Deposition	18	18	18	18	18	18	18	18	18	18	18	18
Manure production	143	150	150	147	182	184	184	183	314	322	322	322
Purchase of fertilizer	152	148	148	144	159	160	160	157	173	171	171	170
Uptake by crop	146	138	138	136	145	144	144	143	155	154	154	153
Manure disposed	0	0	0	37	0	0	0	67	55	61	87	176

Source: Farm Model results LEI-DLO.

Table A6.2 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on dairy farms in Nordrhein-Westfalen

	Low				Medium				High			
	Base	Cap Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	48	47	47	44	67	66	66	61	89	89	88	79
Nitrogen surplus	129	131	131	103	162	165	165	108	217	218	208	120
Deposition	38	38	38	38	38	38	38	38	38	38	38	38
Manure production	118	120	120	118	127	128	128	128	133	134	134	134
Purchase of fertilizer	118	118	118	118	127	128	128	128	133	134	134	134
Uptake by crop	121	121	121	121	124	124	124	123	124	123	123	123
Manure disposed	0	0	0	26	0	0	0	56	10	10	20	107

Source: Farm Model results LEI-DLO.

Table A6.3 *Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on dairy farms in Bretagne*

	Low				Medium				High			
	Base	Cap Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	35	35	35	35	35	36	36	36	47	47	47	46
Nitrogen surplus	82	86	86	86	99	101	101	98	116	118	116	110
Deposition	17	17	17	17	17	17	17	17	17	17	17	17
Manure production	102	105	105	105	135	136	136	135	175	175	176	175
Purchase of fertilizer	82	82	82	83	70	71	71	70	60	61	61	61
Uptake by crop	98	97	97	98	97	96	96	96	101	101	101	101
Manure disposed	0	0	0	0	0	0	0	1	0	0	2	8

Source: Farm Model results LEI-DLO.

Table A6.4 *Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on dairy farms in Lombardia*

	Low				Medium				High			
	Base	Cap Reform	Appli-cation standard	Levy on surplus	Base	CAP Reform	Appli-cation standard	Levy on surplus	Base	CAP Reform	Appli-cation standard	Levy on surplus
Gross margin	8	8	8	8	22	21	21	20	107	106	100	99
Nitrogen surplus	36	46	46	46	123	125	121	112	249	247	156	176
Deposition	23	23	23	23	23	23	23	23	23	23	23	23
Manure production	41	55	55	55	201	204	204	202	511	511	511	511
Purchase of fertilizer	25	20	20	20	66	67	70	67	96	95	116	95
Uptake by crop	39	33	33	33	112	112	112	112	156	153	153	153
Manure disposed	6	8	8	8	13	13	21	25	123	127	239	199

Source: Farm Model results LEI-DLO.

Table A6.5 *Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on dairy farms in the Netherlands*

	Low				Medium				High			
	Base	Cap Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	78	75	72	59	130	125	117	100	102	95	86	75
Nitrogen surplus	274	275	256	263	333	333	268	300	391	391	268	298
Deposition	36	36	36	36	36	36	36	36	36	36	36	36
Manure production	256	257	252	257	331	331	324	329	493	494	431	431
Purchase of fertilizer	224	224	242	213	218	218	249	217	216	216	246	216
Uptake by crop	190	190	190	190	185	184	184	184	183	183	183	183
Manure disposed	0	0	34	0	0	0	91	31	72	72	175	114

Source: Farm Model results LEI-DLO.

Table A6.6 *Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) of the 33% of farms with lowest manure production per hectare (low) and the 33% of farms with highest manure production per hectare (high) and the category in between (medium) on dairy farms in England West*

	Low				Medium				High			
	Base	Cap Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	77	78	78	74	103	103	103	94	91	90	88	79
Nitrogen surplus	123	126	126	98	165	167	166	99	218	218	187	100
Deposition	20	20	20	20	20	20	20	20	20	20	20	20
Manure production	128	131	131	129	183	185	185	184	248	248	248	248
Purchase of fertilizer	97	98	98	97	98	99	99	99	101	101	101	101
Uptake by crop	95	95	95	94	99	99	99	99	101	101	101	101
Manure disposed	0	0	0	27	0	0	1	68	0	0	31	118

Source: Farm Model results LEI-DLO.

Appendix 7 Gross margin and nitrogen balance on granivore farms in the Member States

Table A7.1 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in Belgium

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	117.8	112.5	104.7	103.2
Nitrogen surplus	216	218	198	127
Deposition	33	33	33	33
Manure production	2,201	2,161	1,771	1,783
Purchase of fertilizer	132	134	134	133
Uptake by crops	99	99	99	98
Manure disposed	1,611	1,579	1,287	1,367

Source: Farm Model results LEI-DLO.

Table A7.2 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in Denmark

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	113.1	118.7	115.3	107.8
Nitrogen surplus	221	224	212	101
Deposition	18	18	18	18
Manure production	342	340	338	341
Purchase of fertilizer	132	136	135	130
Uptake by crops	112	112	112	111
Manure disposed	91	89	100	208

Source: Farm Model results LEI-DLO.

Table A7.3 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in Germany

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	57.4	57.1	56.8	53.3
Nitrogen surplus	211	229	218	110
Deposition	34	34	34	34
Manure production	201	219	214	207
Purchase of fertilizer	111	115	114	106
Uptake by crops	89	88	88	86
Manure disposed	6	7	14	110

Source: Farm Model results LEI-DLO.

Table A7.4 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in Greece

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	54.7	54.1	46.9	46.6
Nitrogen surplus	445	446	171	245
Deposition	5	5	5	5
Manure production	8,894	8,894	8,894	8,894
Purchase of fertilizer	34	38	43	38
Uptake by crops	46	48	48	48
Manure disposed	6,664	6,664	6,945	6,866

Source: Farm Model results LEI-DLO.

Table A7.5 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in Spain

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	16.8	17.9	11.6	10.4
Nitrogen surplus	297	306	180	171
Deposition	6	6	6	6
Manure production	1,552	1,623	1,621	1,617
Purchase of fertilizer	52	52	52	52
Uptake by crops	45	45	45	45
Manure disposed	957	1,005	1,129	1,135

Source: Farm Model results LEI-DLO.

Table A7.6 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in France

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	109.6	109.2	102.2	97.7
Nitrogen surplus	240	244	190	118
Deposition	19	19	19	19
Manure production	551	569	534	533
Purchase of fertilizer	97	102	102	100
Uptake by crops	99	100	100	100
Manure disposed	217	231	259	327

Source: Farm Model results LEI-DLO.

Table A7.7 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in Italy

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	130.2	130.8	120.7	119.0
Nitrogen surplus	174	174	146	143
Deposition	20	20	20	20
Manure production	1,858	1,855	1,855	1,855
Purchase of fertilizer	83	87	95	87
Uptake by crops	129	131	131	131
Manure disposed	1,287	1,287	1,323	1,317

Source: Farm Model results LEI-DLO.

Table A7.8 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in the Netherlands

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	119.8	105.0	95.7	94.4
Nitrogen surplus	287	288	216	229
Deposition	36	36	36	36
Manure production	3,271	3,271	3,137	3,224
Purchase of fertilizer	158	158	173	157
Uptake by crops	157	157	157	156
Manure disposed	2,365	2,365	2,345	2,385

Source: Farm Model results LEI-DLO.

Table A7.9 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in Portugal

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	10.8	14.7	12.0	11.2
Nitrogen surplus	250	243	161	112
Deposition	4	4	4	4
Manure production	659	666	667	666
Purchase of fertilizer	15	14	15	14
Uptake by crops	28	28	28	28
Manure disposed	269	280	364	411

Source: Farm Model results LEI-DLO.

Table A7.10 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on granivore farms in the United Kingdom

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	209.2	200.6	189.2	187.0
Nitrogen surplus	282	290	192	100
Deposition	23	23	23	23
Manure production	1270	1301	1286	1331
Purchase of fertilizer	103	105	107	107
Uptake by crops	96	97	97	98
Manure disposed	763	782	869	998

Source: Farm Model results LEI-DLO.

Appendix 8 Gross margin and nitrogen balance on cereal farms in the Member States

Table A8.1 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in Denmark

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	14.1	13.9	14.1	14.1
Nitrogen surplus	57	53	71	71
Deposition	18	18	18	18
Manure production	9	9	9	9
Purchase of fertilizer	135	129	111	111
Purchase of organic manure	0	0	46	45
Uptake by crops	103	100	100	100

Source: Farm Model results LEI-DLO.

Table A8.2 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in Germany

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	13.8	13.5	13.8	13.8
Nitrogen surplus	67	63	80	79
Deposition	31	31	31	31
Manure production	9	9	9	9
Purchase of fertilizer	117	112	96	96
Purchase of organic manure	0	0	42	42
Uptake by crops	88	85	85	85

Source: Farm Model results LEI-DLO.

Table A8.3 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in Greece

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	7.6	7.1	7.2	7.1
Nitrogen surplus	32	30	45	35
Deposition	8	8	8	8
Manure production	11	9	9	9
Purchase of fertilizer	58	60	45	55
Purchase of organic manure	0	0	38	12
Uptake by crops	44	45	45	45

Source: Farm Model results LEI-DLO.

Table A8.4 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in Spain

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	12.2	12.3	12.5	12.5
Nitrogen surplus	12	11	17	17
Deposition	7	7	7	7
Manure production	1	1	1	1
Purchase of fertilizer	35	34	28	28
Purchase of organic manure	0	0	15	15
Uptake by crops	29	29	29	29

Source: Farm Model results LEI-DLO.

Table A8.5 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in France

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	42.8	42.7	43.8	43.7
Nitrogen surplus	52	45	70	69
Deposition	19	19	19	19
Manure production	2	2	2	2
Purchase of fertilizer	145	137	113	114
Purchase of organic manure	0	0	61	59
Uptake by crops	113	110	110	110

Source: Farm Model results LEI-DLO.

Table A8.6 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in Ireland

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	24.9	24.7	25.1	25.1
Nitrogen surplus	39	38	57	57
Deposition	10	10	10	10
Manure production	10	10	10	10
Purchase of fertilizer	139	135	116	116
Purchase of organic manure	0	0	47	47
Uptake by crops	117	114	114	114

Source: Farm Model results LEI-DLO.

Table A8.7 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in Italy

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	6.5	6.3	6.5	6.4
Nitrogen surplus	28	31	55	47
Deposition	13	13	13	13
Manure production	7	7	7	7
Purchase of fertilizer	55	63	40	47
Purchase of organic manure	0	0	59	40
Uptake by crops	42	49	49	49

Source: Farm Model results LEI-DLO.

Table A8.8 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in Portugal

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	7.6	8.0	8.4	8.3
Nitrogen surplus	15	16	38	34
Deposition	4	4	4	4
Manure production	2	2	2	2
Purchase of fertilizer	41	48	26	31
Purchase of organic manure	0	0	55	43
Uptake by crops	31	37	37	37

Source: Farm Model results LEI-DLO.

Table A8.9 Gross margin (x 1,000 ECU) and nitrogen balance (kg N/ha) on cereal farms in United Kingdom

	Base	CAP Reform	Application standard	Levy on surplus
Gross margin	67.4	65.2	66.1	66.0
Nitrogen surplus	46	45	61	60
Deposition	18	18	18	18
Manure production	8	8	8	8
Purchase of fertilizer	112	109	94	93
Purchase of organic manure	0	0	39	38
Uptake by crops	89	88	88	88

Source: Farm Model results LEI-DLO.

LIST OF RELATED PUBLICATIONS

The project *Standards on nitrate in the European Community: Processes of change in policy instruments and agriculture* produced the following reports.

Becker, H. and W. Kleinhanss (1995)
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