Managing nitrogen pollution from intensive livestock production in the EU

Economic and environmental benefits of reducing nitrogen pollution by nutritional management in relation to the changing CAP regime and the Nitrates Directive

Floor Brouwer
Petra Hellegers
Marga Hoogeveen
Harry Luesink

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Agricultural Economics Research Institute (LEI), The Hague

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- ☐ National and international policy issues
- ☐ Farm Accountancy Data Network; Statistical documentation; Periodical reports

Managing nitrogen pollution from intensive livestock production in the EU; economic and environmental benefits of reducing nitrogen pollution by nutritional management in relation to the changing CAP regime and the Nitrates Directive
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This report investigates the role of nutritional management in the reduction of nitrogen pollution from intensive livestock units in Europe. Economic and environmental benefits are assessed in response to the 1992 CAP reform and the Nitrates Directive. In order to achieve a preventive method for the compliance with the Nitrates Directive, strong political directions are required, partly through linkages between agricultural and environmental policies, and nutritional management measures.

Orders:
Phone: 31.70.3308330
Fax: 31.70.3615624
E-mail: publicatie@lei.dlo.nl

Information:
Phone: 31.70.3308330
Fax: 31.70.3615624
E-mail: informatie@lei.dlo.nl

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Preface

The Agricultural Economics Research Institute (LEI) recently undertook a research effort into the role of nutritional management to reduce nitrogen pollution problems from livestock production in Europe. Emphasis was given to the effect of the CAP regime and of the Nitrates Directive on the economic and environmental benefits of nutritional management in reducing nitrogen pollution from intensive livestock production units in Europe. The results are presented in the present report. The study was commissioned by the Environmental Task Force reporting to the Amino-Acid Working Party of the European Federation of Animal Feed Additive Manufacturers (FEFANA).

The study was guided by a Technical Committee. This Committee included members of the Environmental Task Force of FEFANA:
Dr. Howard Simmins (chairman), Rhône-Poulenc Animal Nutrition;
Ir. Jan van den Broecke, Eurolysine; and
Dr. Winfried Heimbeck, Degussa.

We gratefully acknowledge the critical remarks made and useful suggestions given by the Technical Committee during all stages of the project.

Several people of LEI have made important contributions to the project. We gratefully acknowledge the support given by Frans Godeschalk and Kathleen Geertjes with their contributions to the report on European agriculture and trade in agricultural products.

The managing director,

Prof. Dr. L.C. Zachariasse

Executive summary

Managing nitrogen pollution from intensive livestock production in the EU

Nitrogen pollution resulting from agricultural activities is a major threat to the quality of European ground, surface and marine waters. Intensive livestock production is an important source of pollution, due to an insufficient area of land available to these farmers on which to apply the manure. This is particularly relevant where pig and poultry production is concentrated. Cost-effective management to minimise the environmental risk from the excess nitrogen produced is a major concern of the European Union (EU).

The report provides a unique evaluation of the potential economic and environmental benefits of nutritional management measures [1] in reducing nitrogen pollution, by up to 25%, from intensive livestock units within the EU. Economic and environment benefits are assessed in relation to the 1992 Common Agricultural Policy (CAP) reform and the Nitrates Directive. The effects of further reform of the CAP are also evaluated.

The analyses are based on three LEI models:
1. the Cereal and Compound Feed Market Model, evaluating the impact of CAP reform on nitrogen pollution levels from intensive livestock production;
2. the Farm European Mineral Model, assessing changes in nitrogen flows at farm levels in response to future environmental legislation, and exploring linkages between disposal of excess nitrogen and nutritional management measures;
3. models comparing options to dispose of excess manure from livestock with nutritional management measures at regional level (MESTOP and MESTTV).

The analyses show that:
1. the reform of the arable crop regime of the CAP, reducing cereal intervention price, significantly lowers the cost of reducing the protein content of compound feed. The consequent reduction in feed costs enables the pig and poultry sectors to apply nutritional management measures to reduce nitrogen output without compromising profitability throughout the production chain. However world market price of soyabean meal is shown to influence the effectiveness of a reduction in cereal prices due to CAP reform. Hence small incentives, complementary with CAP reform, may be necessary to assure that the shift towards environmentally-friendly practices in feed formulation remain permanent;

[1] Three nutrient management measures were studied:
Current - least cost formulation, ignoring nitrogen output;
Controlled - least cost formulation, taking into account nitrogen output and using typical feed ingredients; and
Potential - formulating to scientifically established nutrient requirements, minimizing nitrogen waste, and using supplementary amino acids not yet available commercially on a large scale.

2. preventive nutritional management to reduce nitrogen output at farm level is economically competitive compared with downstream processing of excess manure (storage, transportation and treatment). Such disposal costs are likely to increase further in the future in response to more stringent rules on the application of livestock manure, which will apply particularly to pig and poultry farms. Therefore practical application of nutritional management measures represents a cost-effective alternative at farm level;
3. in most regions of the EU with intensive livestock production, nutritional management eliminates the need for costly treatment of farm effluents. Using Bretagne as an example, it is calculated, that the application of nutritional management assures that the total amount of manure produced could be disposed of without violating the Nitrates Directive. Therefore nutritional management is a realistic option to avoid the problem of excess manure disposal at regional level.

The report concludes that:

the use of nutritional management measures offers a preventive method for the treatment of nitrogen pollution and, hence, compliance with the Nitrates Directive. To be successful, it requires a high level of participation from the animal farming sector. In order to achieve this, EU, national and regional authorities must provide strong political direction, partly through linkages between agricultural and environmental policies, and nutritional management measures.

Summary

Stating the problem

Nitrogen pollution resulting from agricultural activities has been observed in large areas of Europe and is a major threat to the quality of the European aquatic environment (ground water, surface waters and marine waters). Intensive livestock production is an important source of the pollution, due to an insufficient area of land available to these farmers on which to apply the manure. This is particularly relevant in regions where pig and poultry production is highly concentrated (including the Netherlands, Belgium, Denmark, Germany, the southern part of the United Kingdom, the western part of France, Po valley area of Italy and parts of Catalonia) and the impact on the environment is consequently more severe.

Policy responses to the reduction of nitrogen pollution problems from agriculture mainly derive from the Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources (Directive 91/676/EEC, the Nitrates Directive). The maximum allowable nitrogen from livestock manure, will be gradually reduced over time to a maximum level of 170 kg/ha by the year 2003. A diverse set of measures is being taken by Member States to respond to the requirements of the Nitrates Directive. Emphasis is given by Member States to the application of nutrients, rather than considering the whole chain of nitrogen flows in intensive livestock production. Several Member States, including Germany and the Netherlands, presently keep records of nutrient flows across agriculture through nitrogen balance sheets in an effort to reduce nitrogenous pollution.

Nutritional management, as a preventative measure, has been underestimated when evaluating the methods available to reduce nitrogen pollution. The report is targeted at the pig and poultry industries as nutritional management provides realistic opportunities to reduce the excess load of nitrogen waste produced by them.

Assessments on the potential economic and environmental benefits of nutritional management measures in reducing nitrogen pollution from intensive livestock units, at European Union (EU) level, so far remain limited.

Therefore, the main objective of the report is to investigate the role of nutritional management in the reduction of nitrogen pollution from intensive livestock units in Europe. Economic and environmental benefits are assessed in response to the 1992 CAP reform and the Nitrates Directive

Scenarios evaluated

The report includes 3 scenarios for agricultural policy and nutritional management respectively.

In terms of agricultural policy, it evaluates intervention prices and prices of imported raw materials:

- before the CAP reform of 1992 (*CAP-1988*);

- based on the second year of CAP reform (*CAP-1994*); and
- based on an assumed 10% reduction of the intervention prices for 1995/96 (*CAP-2000*).

For nutritional management, the following criteria were evaluated:
Current nutritional management: this scenario is based on least-cost formulation of diets using feeding stuffs and feed supplements available to commercial companies. It ignores nitrogen output.

Controlled nutritional management: this scenario assumes that the reduction of nitrogen output is now also taken into account in feed formulation. Feed prices may differ from *current nutritional management* as dietary protein level is likely to be reduced to a technically proven limit which does not compromise animal performance.

Potential nutritional management: this scenario formulates feed according to scientifically established nutrient requirements of the animal. As a consequence, dietary protein levels will be very low and nitrogen waste minimized. Compared to the other scenarios, the feed price today will be high. Increased commercial demand may make it economically viable in the future.

Cost savings with CAP reform are greater than cost of nutritional management measures in reducing nitrogen pollution

Nutritional management influences nitrogen output
The evaluation of CAP reform on nitrogen pollution levels was undertaken by the Cereal and Compound Feed Market Model (CCM) of LEI which is a regionalized multi-commodity model for the feed materials available in the European market.

Excretion is an inevitable by-product of digestive and metabolic processes by animals. Phase feeding and dietary restrictions through precision in feed formulation are the strongest tools to reduce nitrogen output by excretion from pigs and poultry.

According to the present state of technical knowledge a reduction of 20 to 25% nitrogen excretion is realistic.

Under *CAP-1994*, the higher costs of *controlled nutritional management* measures to feed pigs (3.6 ecu/ton feed) are more than off-set by the cost savings achieved through the reform of agricultural policy (16.8 ecu/ton feed). Beneficial effects on the environment could be substantial as well because of the lower nitrogen content of feed, which reduced from 27.7 kg N/ton feed (*CAP-1994* with *current nutritional management*) to 23.7 kg N/ton feed (*CAP-1994* with *controlled nutritional management*). Therefore, costs of compound feeds are reduced with CAP reform. In principle, cereals in feed increase and dietary protein level decreases, but the final outcome is dependent on world market influences as described below.

The reform in 1992 of the CAP included changes in market and price policies on cereals. Such measures were aimed at contributing to the achievement of less intensive production methods. Pig production might be affected by CAP in an indirect manner through the reform in 1992 of the arable crops regime. One of the objectives of the reform of the cereals crop regime was to improve the market balance of cereals and to improve the competitive position of the EU regarding cereals consumption to feed livestock. However, it is determined by the price relationship between soya, which is world market-dependent, and cereals, which are

CAP-dependent. As soya price lowers there will be an increase in dietary protein level and, hence, nitrogenous waste. Environmental protection measures, therefore may be required to avoid high dietary protein levels brought about by world market influences.

Nutritional management depends on the cost to remove excess nitrogen from manure
The costs of different measures to reduce nitrogen from manure for the individual producer was evaluated using the Farm European Mineral Model (FEM-model of the LEI). The analysis addressed changes in nitrogen flows in response to policy changes.

Excess nitrogen from manure could be removed from intensive livestock production units (mainly pigs and poultry), but their costs are likely to increase over time due to environmental legislation which increasingly puts pressure on the agricultural sector. Alternatively, nutritional management measures might be taken to reduce excess nitrogen from manure.

In the case of *CAP-2000 controlled nutritional management* will be achievable in the areas where pig production is concentrated, at lower costs than in case of *CAP-1994*. Costs to remove excess manure on average presently exceed 1 ecu/kg N in the Netherlands. This may further increase with rising pressure on the manure market.

So, future environmental legislation will increase disposal cost and provide incentives for nutritional management measures.

Pressures on the manure market will increase in areas where pig production is concentrated
The available options to dispose of excess manure from livestock in Bretagne and the Netherlands were explored using two models developed by the LEI (MESTOP and MESTTV). For Bretagne, about 90% of excess of manure is accounted for by pigs and poultry. Under *CAP-2000, potential nutritional management* would allow the reduction of excess nitrogen from pigs and poultry by almost 40%.

In the Netherlands, excess amounts of nitrogen from pigs and poultry does not change significantly with legislation in response to the Nitrates Directive. Most of livestock manure from intensive livestock production already needs to be disposed of according to current legislation to apply livestock manure. The implication is that intensive production may have to be reduced, but both *controlled* and *potential nutritional management* will contribute to a smaller reduction in the pig population compared with the *status quo*.

In conclusion, CAP reform, by increasing cereal usage (assuming soya prices are not low), will reduce dietary protein to levels where regional manure amounts may be in manageable proportions, except for Flanders and The Netherlands. Additional nutritional management measures will remain beneficial to the intensive livestock holding with insufficient land to dispose of the manure.

Recommendations

Nutritional management should be the primary tool for controlling nitrogen excess from intensive livestock production and meet Nitrates Directive targets

Efforts to meet the requirements of the Nitrates Directive should go beyond the means of livestock manure application (good farming practices) and treatment. Preventive nutritional measures, which have immediate effects and a minimum economical burden, rather than alternative curative measures, should be enforced in synergy with structural changes.

CAP reform supports the process by favouring the increase of cereals in pig and poultry feed, thus reducing dietary protein levels, and consequently reducing the level of nitrogen waste. An important caveat is that environmental protection measures should be considered in order to avoid high dietary protein levels brought about by world market influences, which may negate the environmental benefit of the CAP reform. Therefore, in regions with high levels of nitrogen waste from intensive livestock holdings, a norm of *potential nutritional management* should be included in all feed formulation.

Systems are already in place backed up by practical experience
Various regulatory initiatives in the field of nutritional management have already been taken in several Member States.

Three approaches are made:
1. the mineral book keeping systems monitors the input and output flows of nitrogen at farm level to evaluate the amount of nitrogen applications on farmland exceeding the norms defined by the Nitrates Directive;
2. the standard system relying on a predefined and standardized set of nutritional specifications including limited and controlled dietary protein levels per type of formula ("green feed label");
3. investment subsidies to pig and poultry farm operations to upgrade feeding equipment and allow changing diets in line with requirements of growing animals (phase feeding).

A consistent approach should be established at European level
Harmonization of these regulatory tools should extend to other regions, especially those classified as vulnerable, through information exchange, improved communication of the benefits of nutritional management and the setting up of pilot operations.

Adequate incentives should be put in place to make the nutritional measures operational and effective
A high participation of the animal farming sector to these schemes is crucial. Costs to dispose of the remaining excess amounts of manure can only be reduced if a large share of pig and poultry holdings follow nutritional management measures, allowing for a reduction of the overall environmental bill. This requires a strong political will from the EU, national and regional authorities. Linkages need to be created between agricultural and environmental policies and nutritional management measures.

1. Stating the problem

1.1 Objectives of the report

The primary objective of the present report is to investigate the role of nutritional management to reduce nitrogen pollution from intensive livestock production in Europe. Economic and environmental benefits of nutritional management are assessed at European scale in response to the 1992 CAP reform and the Nitrates Directive (Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources). The key tasks to achieve this are:

- *analyse* the present distribution of livestock production in Europe and assess the present state of nitrogen pollution problems from intensive livestock production;
- *estimate* the current impact of the environmental requirements in policy (e.g. EU Nitrates Directive and national legislation) on intensive livestock production in the EU;
- *review* present knowledge regarding the influence of nutritional management on nitrogen output;
- *assess* the role of agricultural policies and their impact on nutritional management and the environment. This part of the report evaluates the extent to which the CAP reform facilitates nutritional management and the environmental measures identified before;
- *quantify* economic gains of nutritional management versus alternative systems (e.g. distribution or processing of animal manure; reduction of livestock production) in reducing nitrogen pollution from livestock; and
- *develop* recommendations for farmers, national and EU policy, research and monitoring.

1.2 Scope of the report

The present report investigates the effects of the Common Agricultural Policy (CAP) and the Nitrates Directive on the economic and environmental benefits of nutritional management in reducing nitrogen pollution problems from intensive livestock units in Europe. It explores the available options of reducing nitrogen pollution problems from intensive livestock production systems (pigs and poultry) in Europe. Emphasis is given to the role of nutritional management of intensive livestock production. The report is aimed to contribute to a further debate in Europe on this topic, both at national and Community level.

Adjustments of nutritional management from intensive livestock units in Europe can contribute to reducing nitrogen pollution, both in a cost-efficient and environmentally-effective manner. The beneficial effects of nutritional management in Europe may be enhanced in response to changes in agricultural and environmental policies. Assessments on the potential economic and environmental benefits of nutritional management in reducing nitrogen pollution from intensive livestock units so far remain limited. Various initiatives have been taken during the past couple of years at national and regional level, in terms of research and techno-economic studies. The economic implications of using feed additives, for example, are assessed at farm level for the Flanders region in Belgium and the Netherlands by Verbeke and Viaene (1996). Also, Haxsen (1997) assessed economic benefits of nitrogen pollution control by nutritional management of livestock production in Germany. However, these initiatives have been followed in isolation, and no coordination or overview of them has been established in the context of the EU. The present report is aimed to fill this gap.

Nutritional management of intensive livestock production may respond largely to changes in price relations of compound feed raw material. Such price relations largely affect protein content of feed. Protein content of pig diets are 17% in Europe and 14% in the USA. Such dietary differences in protein contents of feed affect excretion levels. Concentration and specialization of intensive livestock production (mainly pigs and poultry) increased in the past in areas with good access to large harbours (e.g. Rotterdam, Antwerp, Gent and Hamburg) for the supply of material to produce feedstuffs at low costs, and are close to the main urban centres. Economies of scale from the available infrastructure of the agribusiness complex is also crucial to maintain competitiveness of this sector. The import of protein ingredients largely contributed to excess amounts of nitrogen from European agriculture and their subsequent contribution to nitrogen pollution problems. Excess amounts of nitrogen are observed whereas application levels of nitrogen on land by far exceed crop requirements.

Nitrogen pollution problems originate to a large extent from agricultural sources; the remaining part originates from municipal sources, industry and sewage purification plants. The share of agriculture in total runoff of nitrogen discharge into surface water and leaching into ground water is assessed to be around 60% (EEA, 1995). Livestock production systems contribute to a significant proportion of the nitrogen pollution burden in large areas of Europe. This includes the impact of livestock production to (a) the pollution of ground water, surface waters and coastal waters through leaching of nitrates and eutrophication, as well as (b) pollution of the atmosphere through emissions of ammonia and their subsequent effect on acidification of soils and water. The environmental impact of livestock production largely varies across regions and farming types. Concentration of livestock production due to economies of scale makes the problem especially acute in some regions. Intensive livestock production largely relies on externally produced proteins (feed ingredients). Approximately 70% of total protein requirements to feed pigs and poultry originate from outside the EU. Losses to the environment arise from excess amounts of nutrients applied which may induce leaching of nitrates and phosphates.

There is a common understanding in Europe that major adjustments are required by livestock production in meeting targets formulated by governments, either at regional, national and Community level. This applies mainly to regions with a high concentration of livestock production, and emphasis on pigs and poultry. A wide variety of adjustment processes need to be considered, including measures at source of pollution (e.g. nutritional and fertilizer management), adjustment of farm structure by reducing intensity of production and by taking end-of-pipe measures (processing and treatment of livestock manure) (figure 1.1). Measures which are most promising are these which achieve the targets on nitrogen emissions cost-effectively. These measures can be classified in a two dimensional chart. The first axis discriminates the time scale in which required measures can be put in place. The second axis distinguishes curative from preventive measures.

In this chart nutritional management appears as the most attractive solution. It is the purpose of this study to qualify its importance and to quantify its potential results where applicable.

	Rapid response	Medium response	Slow response
Curative	Storage and transportation of livestock manure	Slurry treatment	Waste water station
Preventive	Nutritional management	Adapt farm practice	Reduction of livestock density

Figure 1.1 Adjustment processes to reduce nitrogen pollution from livestock production

1.3 Outline of the report

The above mentioned tasks form the basis of the following chapters of the report. Chapters 2, 3 and 4 review the present state of knowledge regarding the first three objectives. This is to be followed by assessments regarding the impact of agricultural and environmental policies on the economic and environmental benefits of nutritional management designed to reduce nitrogen pollution problems in intensive livestock units in Europe (chapters 5, 6 and 7).

Chapter 2 focuses on the extent of nitrogen pollution problems related to intensive livestock production in the EU, both at regional and national level. The structure of pig farming in the EU is analysed. Concentration of intensive livestock production depends on externally produced inputs (mainly feedstuffs); trade flows of compound feed therefore are examined as well.

Chapter 3 explores the policies at EU and Member States level. Environmental concerns are increasingly reflected into policies which could affect intensive livestock production in the EU. This includes both the CAP and Directives regarding quality of the European environment. The main legal instruments in the EU are reviewed in chapter 3, including the role of the Nitrates Directive and the Directive on Integrated Pollution Prevention and Control.

Nitrogen pollution problems can be addressed by nutritional management. The influence of nutritional management on nitrogen output from intensive livestock production in the EU will therefore be reviewed in chapter 4 of the report. Emphasis is given to the changing environment for feed formulation, as well as nutritional strategies for reducing nitrogenous water from livestock production systems. The link between nitrogen pollution and lower crude protein levels in diet is evaluated.

Linkages among nutritional management and the CAP is explored in chapter 5. The extent to which the CAP reform facilitates nutritional management by modifying diet composition and subsequently may reduce nitrogen pollution problems is investigated. However, nutritional management may also respond to changes in environmental legislation. In order to clarify this aspect, possible relationships will be examined between the increasing pressure on the manure market due to stricter environmental legislation (and subsequent rise of disposal costs of livestock manure) and the introduction of nutritional management with lower protein diets (chapter 6). Finally, a wide range of options to dispose of excess manure from livestock are presented and compared in chapter 7.

The impact of nutritional management is assessed both at farm level (chapter 6) and at national level (chapter 7). Chapter 6 focuses on nitrogen from livestock manure, whereas chapter 7 studies the effect on the level of manure as a whole. Their responses to nutritional management measures are not necessarily the same, both aspects are required in order to respond to the reports objectives. Chapter 6 investigates nutritional management by pig holdings. It includes a comparison between costs for manure removal and costs of nutritional management at different stages of agricultural policy in the EU. The assessments focus on granivore farms in a number of regions with high surpluses of nitrogen. Options and costs to dispose excess of manure from livestock are discussed in chapter 7. The results compare the economic gains of nutritional management versus alternative systems; they derive from a modelling tool to explore alternative manure strategies at farm level. Specific studies are made on the region of Bretagne in France and the Netherlands.

Chapter 8 provides a summary of the major findings of the report; also some options for farmers, policy and research are identified in this chapter.

In conclusion, main linkages among chapters are summarised in figure 1.2. Chapter 2 is *introductory* to inform readers of nitrogen pollution problems related to intensive livestock production. This introduction serves as input to a *review* on policy responses (chapter 3) and nutritional management (chapter 4) to reduce nitrogen pollution problems. An important part of the report is to assess the *impact* of CAP reform on nutritional management and subsequently on nitrogen pollution (chapter 5). This analysis provides the basis for an assessment of available options to remove excess nitrogen at farm level (chapter 6) and excess manure at regional level (chapter 7). Chapter 8 is to draw up *conclusions* and identifies options for farmers and policy makers both at national and EU level.

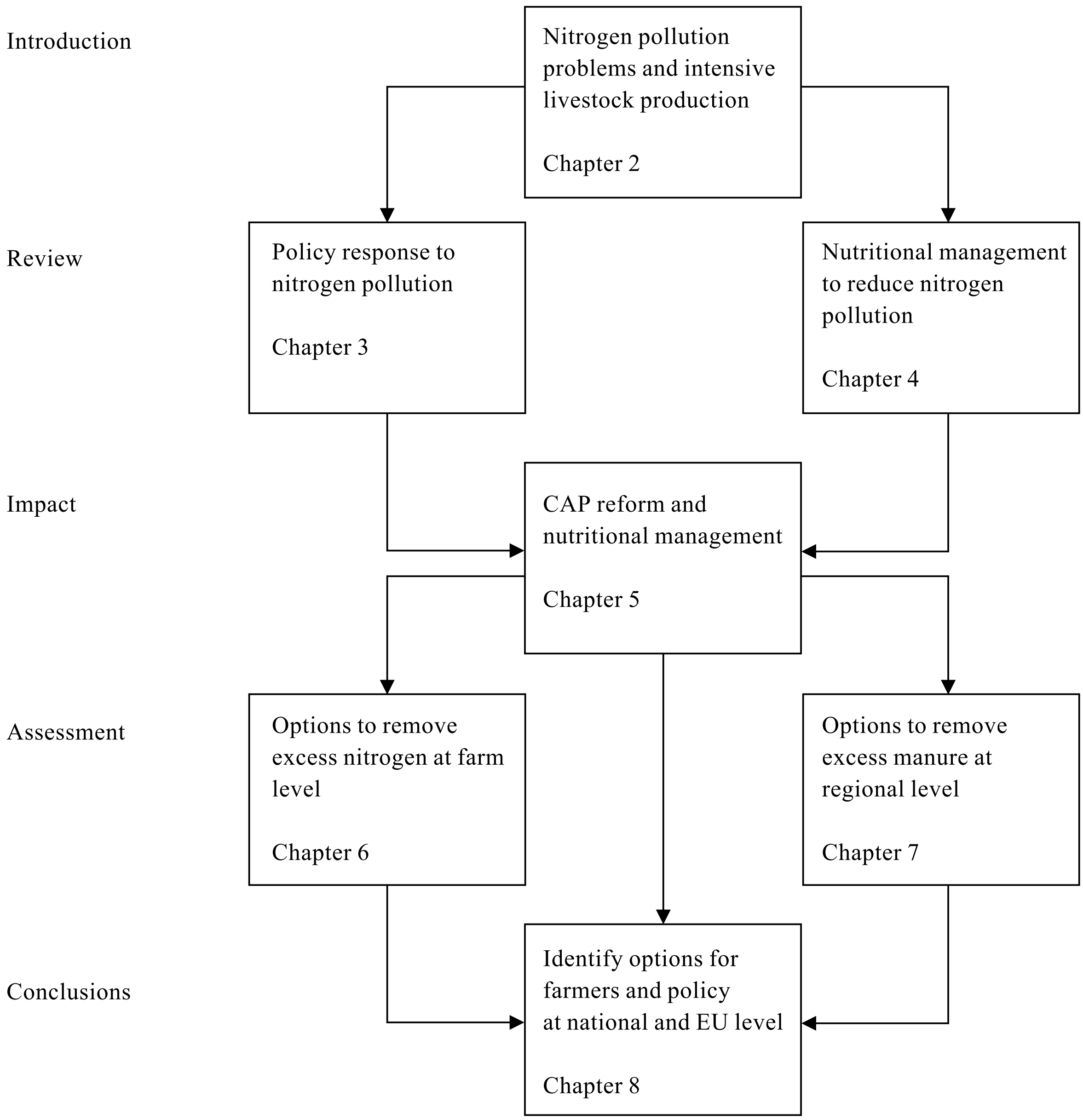

Figure 1.2 Structure of the report

1.4 Approach used and delineation of the report

The report focuses on nitrogen pollution problems related to intensive livestock production. Nitrogen balances are developed as an indicator to monitor response by the agricultural sector to policy targets on nitrogen pollution (i.e. nitrates in drinking water, emissions of ammonia), in terms of adjustment of farming practice and farm management. A schematic presentation of nutrient balances is provided in figure 1.3. The report does not cover the full picture of nitrogen balances. Emphasis is given to link feed concentrates with feed consumption by livestock (chapter 5). Also chapter 6 and chapter 7 link manure with soil surface and manure disposal. Figures on nitrogen surpluses at farm level are derived in chapter 6. The role of roughage and mineral fertilizers however is not considered in the report.

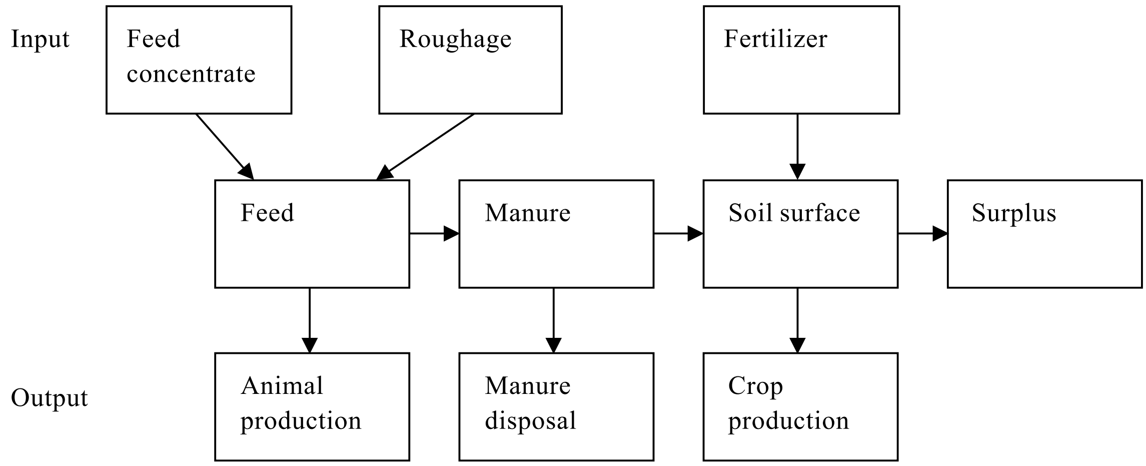

Figure 1.3 Schematic representation of linkages in the nutrient flow balance

Options to reduce nitrogen surplus by adjustment of fertilization strategies for crop production are not considered since nitrogen pollution problems are most acute in regions with excess amounts of manure from livestock production.

Emphasis is given to the role of nutritional management to reduce nitrogen pollution through adjustments of the feeding regime (chapter 4 and chapter 5). This option will be compared with alternative strategies at farm level (chapter 6) and at regional level (chapter 7). Chapters 5, 6 and 7 respectively derive from three models which are described in Appendix A, B and C of the report.

2. Nitrogen pollution problems related to intensive livestock production in the European Union

2.1 Introduction

This chapter puts into context the economic framework of environmental issues by addressing:

1. an up-to-date investigation of livestock production sector in the EU;
2. an investigation of production and trade patterns of pigs and pigmeat among EU countries;
3. an investigation of trade flows of compounds of feed; and
4. a review of nitrogen pollution problems in the EU related to livestock production.

Consequently, it will be evident that the concentration of intensive livestock production is one of the main sources of nitrogen pollution problems from agriculture in the European Union (EU).

2.2 National livestock populations

The main categories of livestock population include cattle and other grazing animals, pigs and poultry. Table 2.1 shows the distribution of livestock population in 1993 for all Member States of the EU. The total size of livestock population is presented in livestock-units (LU). This method enables a summation of animal species according to their feed requirements.

Germany, the Netherlands, France and Spain are the four countries with the largest pig populations. They cover about sixty per cent of the EU-15 total pig population. France, Italy, the United Kingdom and Spain are the countries with largest populations of poultry and they account for more than sixty per cent of the EU-12 total poultry population.

Animal density (i.e. number of livestock units per hectare of utilized agricultural area, LU/ha) is an indicator of the intensity of production which shows a wide differentiation among countries. This is important since it is a rough indicator of the amount of animal manure supplied by livestock (table 2.1). High animal density indicates that more minerals are supplied from animals than could be applied on the field according to the mineral requirements to grow crops. Stocking density however is rather inadequate to depict nitrogen pollution problems as that would depend on a broader range of factors including farm management (e.g. nutritional management, fertilization regime). It is also used in the framework of agricultural policy for the provision of compensatory payments under the beef and sheep regimes, which are subject to compliance with a maximum stocking density on the holding, as discussed in chapter 3 of the report.

Table 2.1 Livestock population, utilized agricultural area (UAA) and animal density in EU-15 in 1993 a)

Country	Cattle	Other grazing animals b)	Pigs	Poultry	Total livestock population (million LU)	UAA (million ha)	Animal density (LU/ha)
	(million animals)						
Belgium	3.2	0.2	7.1	28.6	4.2	1.3	3.1
Denmark	2.2	0.2	11.6	19.8	4.5	2.7	1.6
Germany	15.9	2.4	26.0	86.2	18.7	17.0	1.1
Greece	0.5	12.7	0.8	31.9	2.2	3.5	.6
Spain	4.8	21.5	13.1	104.4	10.4	24.7	.4
France	20.3	11.8	13.9	263.6	22.5	28.1	.8
Ireland	7.0	8.0	1.6	13.0	6.2	4.3	1.4
Italy	7.6	11.9	8.4	149.8	10.5	14.7	.7
Luxembourg	0.2	0.0	0.0	0.0	0.2	0.1	1.2
Netherlands	4.8	2.1	15.0	98.4	7.9	2.0	3.9
Portugal	1.3	3.5	2.6	32.9	2.3	4.0	.6
United Kingdom	11.6	44.6	7.8	144.9	16.0	16.4	1.0
EU-12	79.4	118.9	107.9	973.6	105.5	119.0	.9
Austria c)	2.3	0.5	3.7	14.2	2.7	3.5	.8
Finland c)	1.2	0.1	1.3	9.6	1.2	2.6	.5
Sweden c)	1.8	0.6	2.3	12.6	1.9	3.4	.6
EU-15	84.7	120.1	115.3	1,009.9	111.4	128.4	.9

a) Total livestock population in livestock units (LU); b) Other grazing animals mainly include sheep and goats; c) 1994.
Source: Eurostat (Eurofarm 1993); adaptation LEI.

Cattle is the dominant animal category within the EU (with a share of about half of total livestock population), as based on livestock units, followed by pigs (25% of total livestock population). The share of pigs in national livestock population is highest in Denmark (62%), Belgium and the Netherlands (both 42%) (table 2.2).

Table 2.2 Share of animal categories in national livestock population in EU-15 in 1993 (%) a)

Country	Cattle	Other grazing animals	Pigs	Poultry
Belgium	50	1	42	7
Denmark	33	1	62	4
Germany	57	2	35	6
Greece	17	61	9	14
Spain	33	22	33	11
France	62	6	15	18
Ireland	78	14	6	2
Italy	48	12	21	18
Luxembourg	88	1	10	1
Netherlands	41	3	42	14
Portugal	39	18	28	15
United Kingdom	49	29	12	10
EU-12	51	12	25	12
Austria b)	59	2	34	5
Finland b)	65	1	26	8
Sweden b)	63	3	28	7

a) Composition of animal categories is based on livestock units; b) 1994.
Source: Eurostat (Eurofarm 1993); adaptation LEI.

2.3 Regional livestock populations

Livestock population generally is concentrated in the larger countries in regions where cost advantages may be obtained. Compared to figures at national level, concentration of livestock production at regional level better indicates regions with potential nitrogen pollution problems.

Figure 2.1 shows animal density per hectare of utilized agricultural area at regional level. Animal density exceeds 2 LU/ha in most of the Netherlands, part of Germany (some regions in Niedersachsen and Nordrhein-Westfalen), Bretagne (France), Lombardy (Italy) and some parts of Spain (regions of Galicia and Cataluna). A stocking density of 2 LU/ha is considered to be close to the amounts of nitrogen from livestock manure which might be applied according to the rules of the Nitrates Directive (e.g. according to legislation in Germany, a manure unit is considered to be close to 80 kg of nitrogen).

Table 2.3 shows the size of livestock population for a selected number of regions. Livestock density in these countries and regions are relatively high. No figures are presented on regions where pig production has no major environmental impact (e.g. Greece, Ireland, Luxembourg, Portugal, Finland and Sweden).

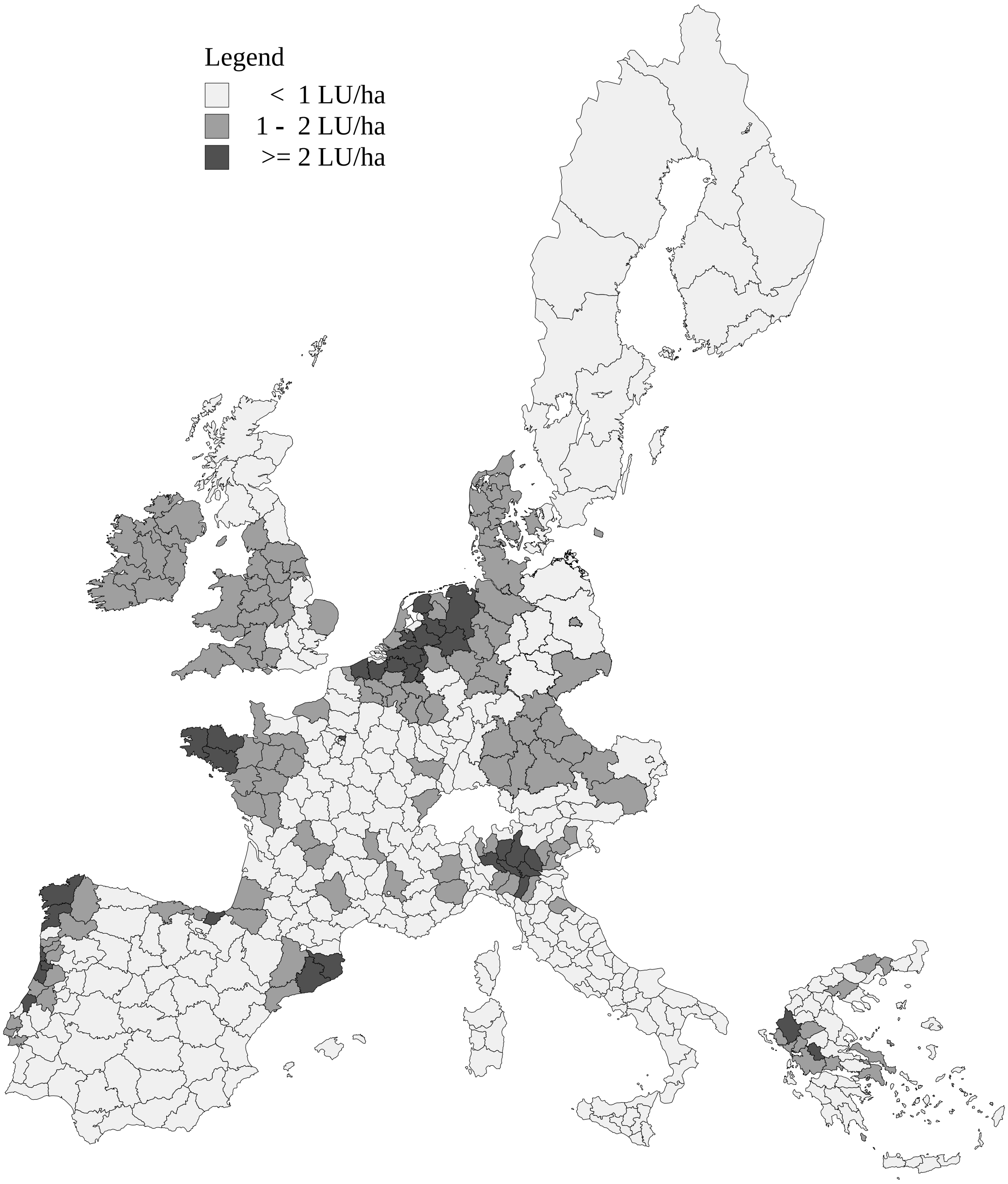

Figure 2.1   Animal density in the EU (number of livestock units per hectare of utilized agricultural area)
Source: Eurostat (Eurofarm 1989/90); adaptation LEI.

Table 2.3 Livestock population, utilized agricultural area (UAA) and animal density by region in EU-15 in 1993 a)

Country	Cattle	Other grazing animals b)	Pigs	Poultry	Total livestock population (million LU)	UAA (million ha)	Animal density (LU/ha)
	(million animals)						
Belgium	3.2	0.2	7.1	28.6	4.2	1.3	3.1
Denmark	2.2	0.2	11.6	19.8	4.5	2.7	1.6
Germany							
- Niedersachsen	3.0	0.3	7.2	39.1	4.4	2.7	1.6
- Nordrhein- - Westfalen	1.8	0.2	5.8	9.9	2.8	1.6	1.8
Spain							
- Galicia	0.9	0.3	0.6	7.6	1.0	0.6	1.7
- Cataluna	0.6	0.9	4.5	38.8	2.1	1.1	1.8
France							
- Pays de la Loire	2.8	0.4	1.5	56.7	3.2	2.2	1.4
- Bretagne	2.4	0.2	7.7	100.4	5.0	1.8	2.8
Italy							
- Lombardy	1.9	0.2	2.9	19.0	2.3	1.1	2.2
- Emilia-Romagna	0.8	0.1	1.9	21.0	1.3	1.2	1.1
Netherlands	4.8	2.1	15.0	98.4	7.9	2.0	3.9
United Kingdom							
- England North	2.2	9.2	2.4	26.7	3.3	2.6	1.3
- England East	1.6	4.3	2.9	51.4	2.9	3.7	.8
Austria c)							
- Oberösterreich	0.7	0.1	1.2	3.4	0.8	0.6	1.4

a) Total livestock population in livestock units (LU); b) Other grazing animals mainly include sheep and goats; c) 1994.
Source: Eurostat (Eurofarm 1993); adaptation LEI.

Intensive livestock systems are generally important in regions with a high density of livestock population. Most of the analysis in the remaining part of the report therefore will focus on specific regions where intensive livestock production is concentrated. The share of pigs and poultry in the regions with a high livestock density exceeds 50% in most of these regions (table 2.4). Poultry account for more than 20% of the regional livestock population in parts of France (Pays de la Loire, Bretagne), Spain (Cataluna) and the United Kingdom (England East). Furthermore, livestock density is highest at farms with intensive livestock systems (mainly pigs and poultry). Table 2.5 for example shows density of livestock population at the different farming types in the EU. The relatively small size of utilized agricultural area by granivore farms, and the high density of livestock population are a major determinant of the high levels of nitrogen surpluses at such holdings.

Table 2.4 Share of animal categories in the regional livestock population in EU-15 in 1993 (%) a)

Country	Cattle	Other grazing animals	Pigs	Poultry
Belgium	50	1	42	7
Denmark	33	1	62	4
Germany				
- Niedersachsen	44	1	44	11
- Nordrhein-Westfalen	41	2	52	5
Spain				
- Galicia	72	5	16	7
- Cataluna	17	5	58	21
France				
- Pays de la Loire	59	2	11	28
- Bretagne	34	1	37	29
Italy				
- Lombardy	54	1	34	11
- Emilia-Romagna	45	2	37	17
Netherlands	41	3	42	14
United Kingdom				
- England North	44	28	18	9
- England East	36	16	25	23
Austria b)				
- Oberösterreich	59	1	36	4

a) Composition of animal categories is based on livestock units; b) 1994.
Source: Eurostat (Eurofarm 1993); adaptation LEI.

Table 2.5 Livestock density (LU/ha) and number of holdings (x 1,000) of different farming types in the EU

	Dairy farms	Drystock farms	Granivore farms
Density	1.7	1.0	20.5
Number of holdings	589.7	502.7	60.7

Source: Brouwer et al. (1995).

2.4 Structure of pig farming

It is critical to understand the different bases by which pigs are farmed in order to identify the appropriate processes necessary to reduce nitrogen pollution. Also they may indicate differences in the way these holdings might respond to changes in environmental legislation, to available technical options and to constraints put on farming practice. Therefore, the distribution of pig population among farming types is being presented in this section. Table 2.6 shows the composition of pig population according to the six most represented farming types. Specialized pig holdings (farming type 50) account for over half of pig population in most of the regions considered, with the exception of Denmark, Germany, parts of Spain and France. These types of specialist farms even cover around 75 per cent of pig population in Lombardy and Emilia-Romagna. These regions include a limited number of very large farms with a livestock population of around ten thousand pigs, which is rare elsewhere in the EU.

Table 2.6 Share of pig population of six major farming types in the regional pig population (%) and pig population (million animals) in 1989/90 by region

Region	Farming type a)						Pig population
	12	41	50	71	72	82	
Belgium	1	5	54	5	22	7	6.7
Denmark	7	2	37	4	3	42	9.2
Germany							
- Niedersachsen	16	7	8	13	11	28	7.1
- Nordrhein-Westfalen	10	5	6	13	9	39	5.8
Spain							
- Galicia	1	20	36	9	13	2	0.6
- Cataluna	1	1	54	4	12	18	3.8
France							
- Pays de la Loire	1	2	30	5	46	10	1.0
- Bretagne	0	1	58	4	26	9	6.6
Italy							
- Lombardy	1	1	76	3	9	7	2.9
- Emilia-Romagna	1	1	74	1	10	8	1.9
Netherlands	1	11	63	1	17	5	13.8
United Kingdom							
- England North	8	2	55	1	6	23	2.3
- England East	12	1	50	1	4	26	2.8

a) Principal types of farming, according to the Community typology for agricultural holdings:
Type 12: General field cropping;
Type 41: Specialist dairying;
Type 50: Specialist granivores (intensive livestock farms);
Type 71: Mixed livestock, mainly grazing livestock;
Type 72: Mixed livestock, mainly granivores;
Type 82: Various crops and livestock combined.
Source: Eurostat (Eurofarm 1989/90); adaptation LEI.

The share of pig population in farming type 82 (farms with various crops and livestock combined) is largest in Denmark (42%). It is also high in some regions of Germany and the United Kingdom. The share of home-grown feedstuffs in total feeding costs is high as well in these regions (table 2.7).

Table 2.7 Revenues and costs for feedstuffs to feed pigs and poultry on the farms selected from FADN by region and by farming type (average 1991/92 - 1993/94)

Region/ farming type a)	Revenues			Costs of feedstuffs for pigs and poultry	
	total	pigs	poultry	total (1,000 ecu/ holding)	of which home-grown (%)
	(1,000 ecu)				
Belgium					
-Type 5013	249	231	0	141	2
-Type 7210	181	96	12	68	1
-Type 8210	139	88	4	54	6
Denmark					
-Type 5013	312	263	1	140	13
-Type 8210	129	83	4	54	25
Germany					
Niedersachsen					
-Type 5013	125	103	0	54	11
-Type 7210	140	72	6	44	11
-Type 8210	136	82	5	55	26
Nordrhein-Westfalen					
-Type 5013	159	121	0	65	27
-Type 7210	138	65	2	39	27
-Type 8210	124	74	4	48	42
France					
Bretagne					
-Type 5013	308	255	0	154	6
-Type 7210	160	77	2	51	5
-Type 8210	191	113	19	84	10
Netherlands					
-Type 5013	302	281	1	168	0
-Type 7210	232	102	39	88	0
United Kingdom					
England North					
-Type 5013	419	358	0	243	1
England East					
-Type 5013	337	307	0	185	4
-Type 8210	463	269	36	197	13

a) Type 5013: Pig rearing and fattening combined;
Type 7210: Mixed livestock; granivores and dairying combined;
Type 8210: Field crops and granivores combined.
Source: FADN-CCE-DG VI/A-3; adaptation LEI.

The share of home-grown feed shows major differences among the regions considered. The share of home-grown feedstuffs in total feed costs is highest at farms with field crops and granivores combined (farming type 8210). The on-farm use of cereals to feed pigs may be relatively important for this farming type.

Pigs generate more than 90% of the total revenue on farms with combined pig rearing and finishing (farming type 5013) in Belgium, the Netherlands and East England. This share also exceeds 75% in the other regions. Here, the on-farm use of cereals is negligible.

2.5 Production and trade of pigs and pigmeat

Competitiveness of livestock production is important in an examination of options to reduce nitrogen pollution problems from agriculture. Competitiveness of pig production is an issue of concern, both to the agricultural business sector and policy makers. Cost-effective measures are required to reduce nitrogen pollution problems from livestock. Such measures for example would be required to meeting the objectives of the Nitrates Directive. Pig production is an important sector from an economic point of view, with homogeneous production regions. However, with the trend of liberalization of trade, which will further accelerate under the next round of WTO agreement, it is of paramount importance to keep the pig and poultry industry competitive compared with outside EU producers.

Trade flows of pigs and pigmeat result from, among others, competitive advantages through innovation, rationalization of production processes and integration of chains in the production process. Also important in this respect is to perceive new markets opportunities that have been ignored before (Porter, 1990). Germany, France, the Netherlands and Spain have highest shares in final pig production. The contribution of these four countries in the final pig production of EU-12 amounts to over 60 per cent (table 2.8).

Table 2.8 Final pig production during the period 1982-1994 (Share of national final pig production in EU-12, in %; total of EU-12 and of the Member States by country, in million ecu)

Country	1982	1986	1990a)	1990b)	1992	1994	1994 (mln.. ecu)
	%						
Belgium	6	6	6	5	7	7	1,337
Denmark	8	9	9	9	9	10	2,015
Germany	27	25	22	25	24	22	4,507
Greece	2	1	1	1	1	1	234
Spain	10	11	13	12	13	14	2,730
France	13	13	14	14	14	14	2,878
Ireland	1	1	1	1	1	1	252
Italy	10	11	11	11	11	10	2,077
Luxembourg	0	0	0	0	0	0	14
Netherlands	12	13	13	13	12	12	2,485
Portugal	2	2	2	2	2	2	412
United Kingdom	8	7	7	7	6	6	1,273
EU-12 (mln.. ecu)	19,462	19,524	20,814	21,630	24,230	20,217	20,217

a) Excluding the Neue Bundesländer; b) Including the Neue Bundesländer.
Source: Eurostat (data base New Cronos); adaptation LEI.

The share of final pig production during that period also was stable across the main production regions. However, concentration of pig production increased in France and Italy. Bretagne presently has a share in national pig production of more than 50%. This also applies to Lombardy, showing an increase of regional final production in national total from 22 to 37% (table 2.9).

Table 2.9 Share of regional final pig production as a percent of national total between 1982 and 1994. Final pig production in million ecu in 1994

Country/region	Regional share in national final pig production (%)						Final pig production in 1994
	1982	1986	1990a)	1990b)	1992	1994	
Germany							
- Niedersachsen	31	32	33	28	29	30	1,349
- Nordrhein-Westfalen	26	26	28	24	23	24	1,091
Spain							
- Galicia	7	8	7 c)	.	.	.	201 c)
- Cataluna	33	29	30 c)	.	.	.	892 c)
France							
- Pays de la Loire	8	9	10	10	11	11	328
- Bretagne	44	48	53	53	52	53	1,537
Italy							
- Lombardy	22	31	33	33	34	37	772
- Emilia-Romagna	25	24	24	24	21	20	422
United Kingdom							
- England North	27	28	30	30	30	30	383
- England East	41	38	37	37	38	37	474

a) Excluding the Neue Bundesländer; b) Including the Neue Bundesländer; c) Final pig production in 1989.
Source: Eurostat (data base New Cronos); adaptation LEI.

The Netherlands, Denmark and Belgium are the most important countries of origin for the export of pigs and pigmeat. Table 2.10 provides information on the origin of the import patterns of pigs and pigmeat in the EU countries. The Netherlands is the most important country in this respect with a share of a third of the import value in any of the EU-countries. Denmark is the second country with a share of some 20%. The import of pigs and pigmeat from non-EU countries to the EU is negligible. It presently is less than 1% of total import value to the EU-countries.

The destination of export flows from the Member States is now examined (table 2.11). The total export value of pigs and pigmeat in 1994 to Germany, Italy, the United Kingdom and France amounts to well over 5 billion ecu. This covers over 80% of the intra-trade of pigs and pigmeat in EU-12. The share of the export to outside the EU presently is around 20%. Over 90% of the export of pigs and pigmeat from EU countries to Japan originates from Denmark (table 2.12). Denmark has a strong position in this respect because it is meeting the strict veterinary requirements for the Japanese market.

Table 2.10 Origin of the import of pigs and pigmeat in the EU-12 between 1986 and 1994 a). (Values in million ecu)

Origin	1986	1988	1990	1992	1994
Netherlands	2,028.2	1,976.9	2,434.8	2,563.1	1,831.6
Denmark	1,019.0	969.5	1,299.7	1,591.2	1,287.4
Belgium/Luxembourg	800.2	814.3	944.7	1,259.6	941.3
Germany	348.2	312.0	394.0	409.8	324.5
France	167.7	206.0	336.3	569.2	515.9
Italy	109.2	132.6	153.6	191.3	167.7
United Kingdom	111.1	98.8	123.3	239.5	181.5
Ireland	72.6	73.2	109.7	190.1	142.3
Spain	0.5	0.8	24.7	82.5	173.6
Total EU	4,657.1	4,584.3	5,821.4	7,096.6	5,571.5
Total non-EU	176.5	111.7	119.9	107.9	45.8
World	4,833.7	4,696.3	5,942.0	7,204.6	5,617.3

Source: Eurostat.

Table 2.11 Destination of the export of pigs and pigmeat of the EU-12 between 1986 and 1994 a). (Values in million ecu)

Destination	1986	1988	1990	1992	1994
Germany	1,055.5	1,177.5	1,457.4	2,246.5	2,255.4
Italy	1,142.2	1,030.2	1,344.0	1,563.9	1,261.3
United Kingdom	819.8	918.3	1,146.2	1,098.2	951.1
France	955.6	838.0	948.9	972.7	781.2
Belgium/Luxembourg	230.5	197.6	297.5	325.7	280.4
Spain	155.4	73.4	184.4	229.3	133.3
Greece	147.7	158.3	157.7	179.0	165.5
Netherlands	67.5	91.2	114.7	198.0	207.2
Total EU	4,629.2	4,585.3	5,775.6	7,006.3	6,260.5
Japan	375.4	514.7	420.7	579.9	674.1
USA	368.1	280.2	286.8	188.3	252.0
Russian Federation	-	-	-	14.4	197.5
Total non-EU	908.9	1,093.0	1,169.2	1,145.9	1,761.4
World	5,539.2	5,680.4	6,948.6	8,154.1	8,021.9

a) Including intra trade patterns between the Member States. Only those countries of destination are included which did have a share of at least 2% of total import in the EU during any year between 1986 and 1994. The trade figures of 1986 belong to a recorded group of products. There is a break in the trade statistic product codes between 1987 and 1988.There also is a break in the trade statistics between EU Member States between 1992 and 1993.
Source: Eurostat.

Table 2.12 Destination of the export of pigs and pigmeat from the five most important exporting Member States and the EU-12 in 1994 a). (Values in million ecu)

Destination	Exporting countries					
	France	Belg/Lux.	Netherlands	Germany	Denmark	EU-12
Germany	138.5	570.9	869.8	-	431.7	2,255.4
Italy	234.3	177.4	509.7	122.3	165.4	1,261.3
United Kingdom	48.8	34.9	249.1	21.1	479.9	951.1
France	-	190.4	162.2	43.8	200.6	781.2
Belgium/ Luxembourg	75.4	-	119.2	44.8	6.3	280.4
Netherlands	13.2	111.1	-	26.7	26.8	207.2
Greece	14.5	13.0	98.1	3.3	32.7	165.5
Total EU	577.8	1,133.4	2,090.4	282.0	1,357.3	6,260.5
Japan	2.5	0.0	16.3	2.3	634.9	674.1
USA	1.2	9.9	15.6	0.1	210.9	252.0
Russian Federation	31.3	20.0	11.8	63.5	63.2	197.5
Total non-EU	125.0	46.8	126.9	91.0	1,180.2	1,761.4
World	702.8	1,180.3	2,217.3	373.0	2,537.5	8,021.9

a) Including intra trade patterns between the Member States. Only those countries of destination are included which did have a share of at least 2% of total export of the EU in 1994.
Source: Eurostat.

Countries like Belgium, Denmark, France and the Netherlands are large exporters of pigs and pigmeat. As a consequence, the nitrogen excreted remains in the country resulting in excess nitrogen load for the capacity of the land.

2.6 Trade flows of compound feed

The Netherlands is the biggest importer of compound feed in the EU, because of the high intensity of livestock production. In that country, the total import of feed (exclusive of cereals) in 1994 was equivalent to around 380 thousand tonnes of nitrogen, with more than two thirds of it originating from outside the EU (table 2.13).

The import of feed ingredients from outside the EU is around 70% of total import of feed ingredients in the EU as a whole, mainly used for intensive livestock production in regions with a concentration of pigs and poultry. Total import in the Netherlands is almost 18% of total import of feed (from inside as well as outside the EU) in the Member States. The import of soyabean products has a large share in total import of compound feed. About 80% of the import in the EU Member States of soyabean products originates from outside the EU, mainly from the USA, Brazil and to a lesser extent also from Argentina.

Table 2.13 Import of feed ingredients (exclusive of cereals), expressed in 1,000 tonnes of nitrogen by Member State in 1994

Origin\Destination	F	BLEU	NL	BRD	I	UK	IRL	DK	GR	PT	ES	Total
F	-	22.8	9.3	9.8	11.3	6.6	1.7	0.6	1.3	0.9	4.6	68.8
BLEU	64.2	-	19.4	2.5	0.7	11.9	1.7	0.5	0.1	0.3	0.3	101.5
NL	15.5	52.1	-	81.2	3.9	46.6	11.1	5.6	1.8	0.2	0.7	218.7
BRD	8.5	9.4	91.4	-	1.1	17.3	2.7	18.0	0.4	0.0	0.3	149.1
I	1.9	0.2	0.2	0.2	-	1.0	0.4	0.1	1.5	0.0	0.2	5.7
UK	4.2	2.3	3.1	0.8	1.2	-	17.7	2.1	0.2	0.2	0.6	32.2
IRL	1.0	0.9	0.2	0.0	0.0	6.0	-	0.0	0.0	0.0	0.0	8.2
DK	0.6	0.5	1.8	4.3	3.8	3.7	0.4	-	2.3	0.1	0.9	18.4
GR	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	-	0.0	0.0	0.2
PT	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	1.4	1.4
ES	2.2	0.0	0.1	0.0	0.5	1.2	1.0	0.2	1.9	3.6	-	10.6
EU	98.0	88.2	125.5	98.9	22.8	94.0	36.7	27.1	9.6	5.3	8.9	614.9
From outside EU	276.7	105.2	256.0	170.5	181.2	149.0	37.2	143.1	13.6	33.6	181.3	1,547.2
Total	374.6	193.3	381.4	269.3	203.9	243.0	73.9	170.1	23.2	38.9	190.2	2,162.1
Of which soyabean products												
EU	49.1	15.4	6.5	52.1	0.2	60.3	9.2	13.1	0.9	0.3	1.4	208.5
From outside EU	230.6	66.9	111.0	78.0	128.9	52.7	10.9	94.5	13.3	19.3	135.8	941.9
Total	279.7	82.4	117.5	130.1	129.1	112.9	20.2	107.6	14.1	19.6	137.1	1,150.4

Source: Eurostat; adaptation LEI.

2.7 Nitrogen pollution from intensive livestock units

The quality of the available drinking water resources is one of the most important issues of environmental concern in areas with intensive livestock population. Major losses to the environment of nitrogen emissions from agriculture arise from leaching of nitrates to surface waters and ground water, emissions of ammonia to the atmosphere, as well as denitrification. High supply levels of animal manure from intensive livestock farming may create problems of water and soil pollution. This is due to either the high surplus of nitrogen from agriculture or due to vulnerability of the soil to leaching, or a combination of these two phenomena.

Nitrate levels of 50 mg/l (EU drinking water standard) and more may be expected in about 25% of the agricultural soils in the EU. This applies particularly in the Netherlands, Denmark, Belgium, Germany, the southern part of the United Kingdom, the Po valley area in Italy, and the western part of France (RIVM and RIZA, 1991). Also, eutrophication of surface waters is a particular problem in certain areas of Europe, and high levels of phosphate and nitrates cause eutrophication of surface waters and affect biodiversity through the depletion of plant and animals, and growth of algae. Similarly, emissions of ammonia contribute to acidification of soils and water, and agriculture also contributes to this type of pollution (Brouwer and Van Berkum, 1996).

Nitrogen pollution problems arise to a large extent from intensive livestock production units with excess amounts of nitrogen from livestock manure. This section addresses the current extent of such nitrogen pollution burden in the EU. It identifies regions with massive manure and quantifies nitrogen surpluses for regions with potential leaching of nitrates into water courses.

Evaluation of mineral balances is used as a tool to provide insight into flows of nitrogen across agriculture. Mineral balances are considered to be good indicators for farmers to increase their understanding into the kind of adjustment processes which might contribute to a reduction of nitrogen surplus and a subsequent reduction of nitrate leaching. Mineral balances are defined as the difference between input and output flows. Input flows compare:

1. nitrogen from inorganic fertilizers;
2. nitrogen from organic manure (exclusive of losses due to emissions of ammonia); and
3. nitrogen by deposition from the atmosphere.

Output flows include the uptake of harvested crops. The concept of mineral balances may prevent measures being taken to reduce surpluses in one part of the chain while possibly increasing surpluses in another part of the chain. Regional assessments of nitrogen surpluses in the EU are based on Schleef and Kleinhanss (1994).

Manure production estimates have been derived from coefficients on the excretion of minerals from livestock. Mineral balances at farm level are calculated on the basis of the 1992/93 sample of the Farm Accountancy Data Network (FADN) of the European Commission. Manure production figures are based on the Farm Structure Survey of Eurostat. Table 2.14 presents results of national averages and regional averages of the regions in the relatively large Member States of EU-12 with high surpluses.

Table 2.14 Supply of nitrogen from production of animal manure and nitrogen surplus (kg N/ha) across regions and Member States in 1993/94

Country/region	Manure production		Nitrogen surplus a)
	total livestock	pigs and poultry	
Belgium	283	77	206
Denmark	112	55	109
Germany	70	18	117
- Niedersachsen	93	36	125
- Nordrhein-Westfalen	100	41	138
Greece	47	8	38
Spain	28	9	22
- Galicia	123	20	73
- Cataluna	92	65	278
France	53	11	49
- Pays de la Loire	91	22	83
- Bretagne	157	79	120
Ireland	115	5	71
Italy	46	12	15
- Lombardy	133	40	85
Luxembourg	116	6	107
Netherlands	338	111	319
Portugal	39	13	-3
United Kingdom	70	9	39
- England East	48	15	46
EU-12	62	15	64
Austria b)	52	13	c)
Finland b)	31	7	c)
Sweden b)	40	8	c)
EU-15	61	15	c)

a) 1992/93; b) 1994; c) not available.
Source: FADN-CCE-DG VI/A-3; Eurostat FSS 1993; adaptation LEI.

The amount of manure produced from livestock production across Member States ranges between less than 50 kg N/ha (Greece, Spain, Italy, Portugal, Finland and Sweden) and over 250 kg N/ha (Belgium and the Netherlands) (table 2.14). Nitrogen surplus varies across Member States between -3 kg/ha (Portugal) and 319 kg/ha (the Netherlands). The surplus in Portugal is negative since the uptake of nitrogen by harvested crops is assessed to exceed the input levels that are available for plant growth. Nitrogen surpluses exceed the average of all farms in EU-12 (64 kg N/ha) in Belgium, Denmark, Germany, Ireland, Luxembourg and the Netherlands. Manure production levels in these countries also exceed the average of EU-15 (61 kg N/ha).

Because of the concentration of intensive livestock production in Europe, a limited number of regions have a relatively large proportion of nitrogen surpluses in Europe. This also reflects the large regional variation of nitrogen surpluses across regions. Recent assessments indicate that surpluses remain below 50 kg N/ha on almost half of the agricultural land in the

EU. They however exceed 100 kg N/ha on some 22% of the area. Surpluses exceed 200 kg/ha on only 2% of the agricultural land, mainly in Belgium and the Netherlands. Livestock manure is the most important factor determining surpluses in regions with high surpluses (Schleef and Kleinhanss, 1997). Pigs and poultry production is concentrated in regions with high surpluses which exceed 100 kg N/ha.

Regional differences in nitrogen surplus are largest in Germany, Spain, France and Italy, and relatively small in Greece, Portugal and the United Kingdom. In France for example, nitrogen surplus is in the range between 6 kg/ha (Limousin) and 120 kg/ha (Bretagne). This is mainly due to differences between these regions on the level of nitrogen input from fertilizers (respectively 17 and 97 kg/ha). Manure production in Bretagne is more than double that of Limousin. Production of nitrogen from manure in France varies between 2 kg/ha (Ile de France, with agriculture to be specialized in cereal production) and 157 kg/ha (Bretagne, where agriculture is specialized in livestock production including pigs, poultry and cattle). Moreover, locally in these regions the nitrogen surpluses may reach much higher levels. Although nitrogen surplus is due to agriculture as a whole, livestock in regions where intensive livestock production is concentrated, creates the most serious problems of leaching of nitrates to water. Nitrogen surpluses also are a major issue in regions with the 'hot spots' of intensive livestock production. The relationship between nitrogen surpluses and nitrogen pollution problems is not direct, and also depends on soil and climatic conditions. Wendland et al. (1993) however identify regions vulnerable to nitrate leaching in case nitrogen surpluses exceed 100 kg/ha. Nitrogen surpluses are serious in regions with a high density of intensive livestock production. They exceed 100 kg/ha in Belgium, Denmark, large areas of Germany (among others Schleswig-Holstein, Niedersachsen, Nordrhein-Westfalen, Bayern), the region of Cataluna (Spain), Bretagne (France), Luxembourg and the Netherlands (figure 2.4).

Supply of nitrogen from production of animal manure in the EU exceeds 100 kg/ha in Belgium, Denmark, parts of Germany, large areas of Spain (Galicia, Cantabria), the region of Bretagne in France, Ireland, the northern part of Italy (Lombardy), Luxembourg, the Netherlands and the western part of the United Kingdom (figure 2.2). Manure production from pigs and poultry reach high levels in some of these regions. On a per hectare basis they exceed 50 kg of nitrogen in most of the Netherlands, the region Flanders (Belgium), Bretagne, parts of Denmark, the northern part of Italy and the north-eastern part of Spain (figure 2.3).

Nitrogen surpluses of granivore farms on average are around 700 kg N/ha in EU-12. They are much lower at the other farming types (Brouwer et al., 1995). Nitrogen surpluses largely vary across farms because of differences in farm structure, cropping plan, livestock composition and management practices. Within the group of granivore farms, they also differ largely across individual farms. Nitrogen surplus exceeds 1,000 kg N/ha on around half of all granivore farms across EU-12 (Brouwer and Hellegers, 1997) (see also figure 2.5). Farm size (in terms of utilized agricultural area) is an important factor in this respect, since this farming type includes a considerable share of holdings with very small areas of land.

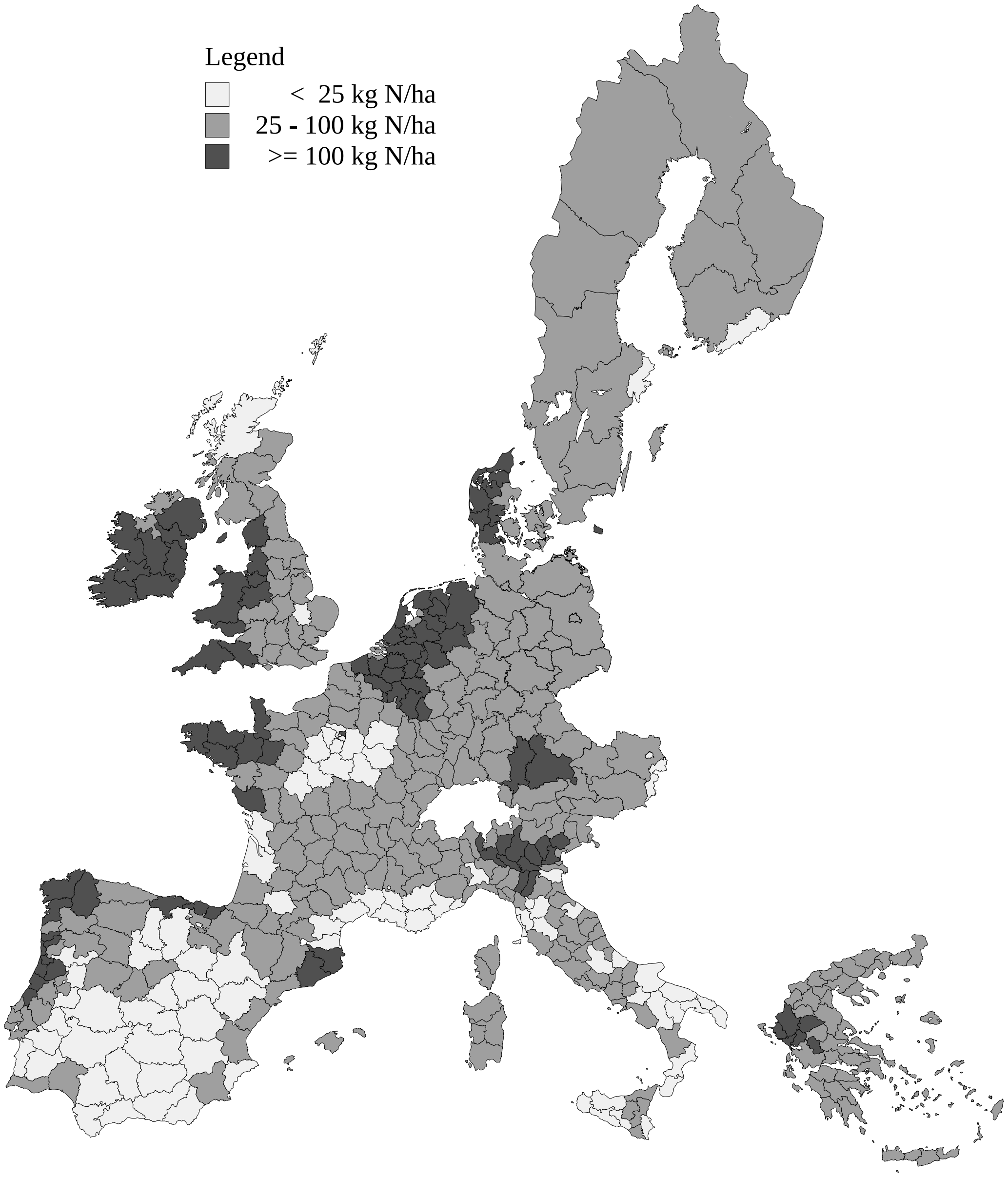

Figure 2.2 Supply of nitrogen from production of animal manure in the EU by region in kg N per ha
Source: FSS-1989/90, adaptation LEI.

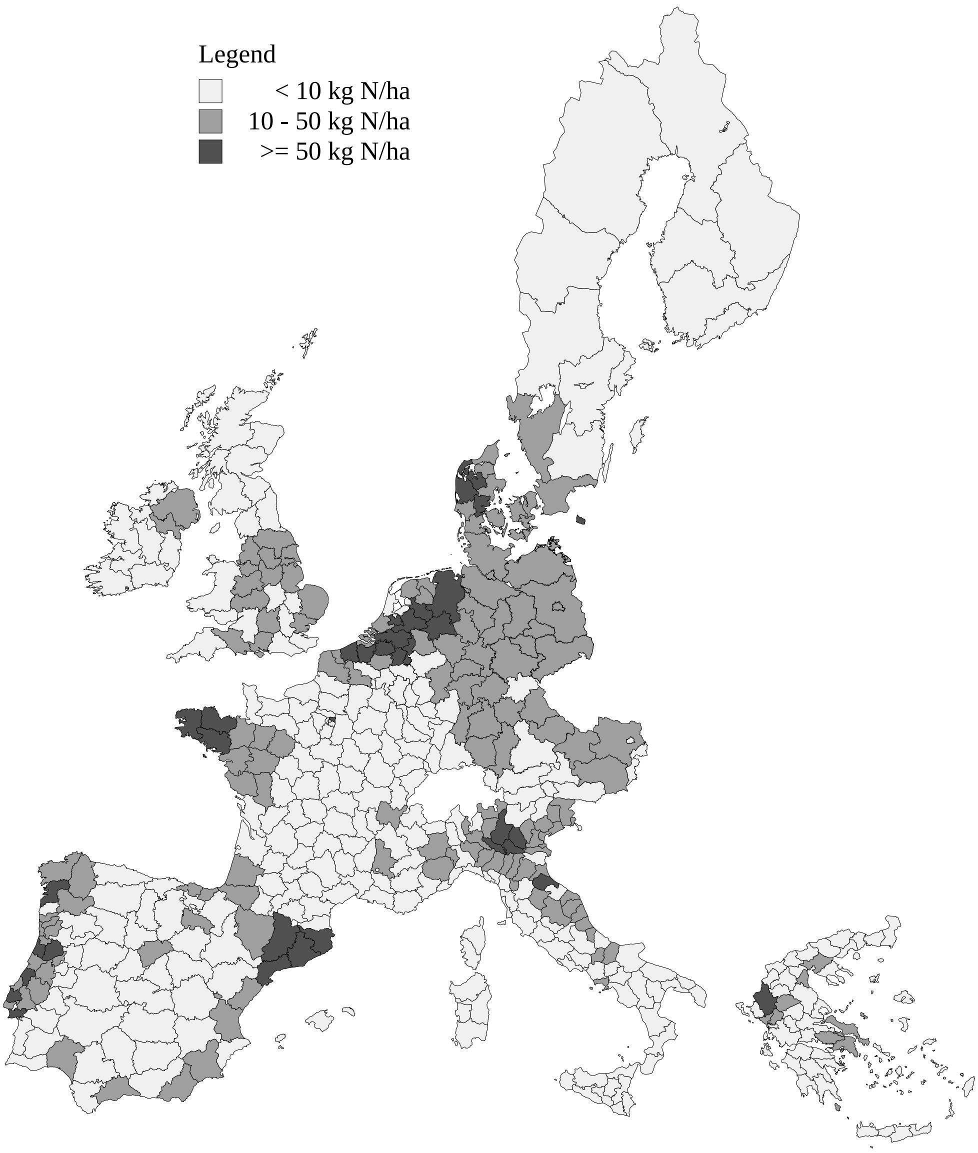

Figure 2.3   Supply of nitrogen from production of pigs and poultry manure in the EU by region in kg N per ha
Source: FSS-1989/90; adaptation LEI.

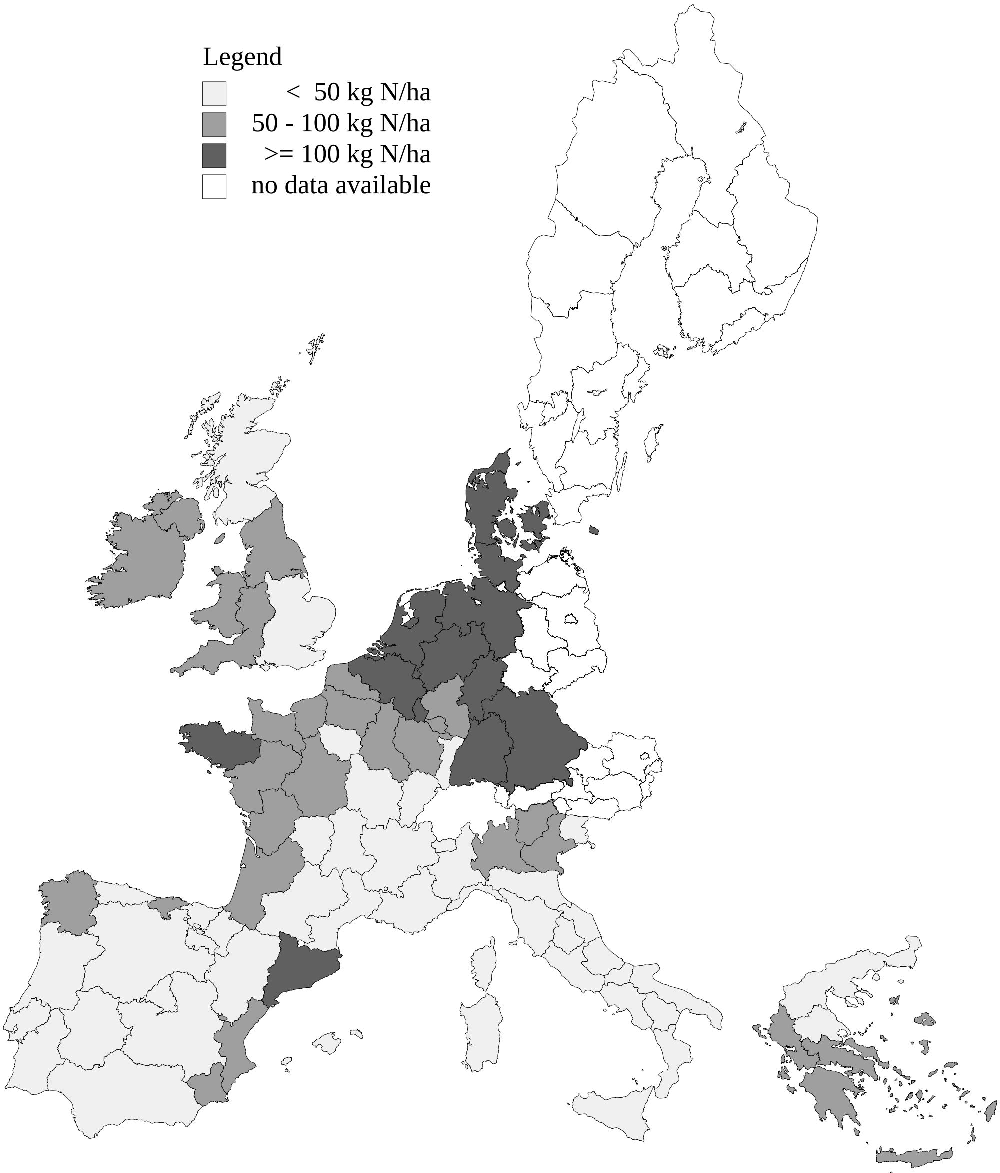

Figure 2.4 Nitrogen surplus (inputs of nitrogen from livestock manure, mineral fertilizers and other nitrogen sources, minus uptakes of nitrogen from harvested crops) in the EU by region in kg N per ha in 1992/93

Source: FADN-CCE-DG VI/A-3; adaptation LEI.

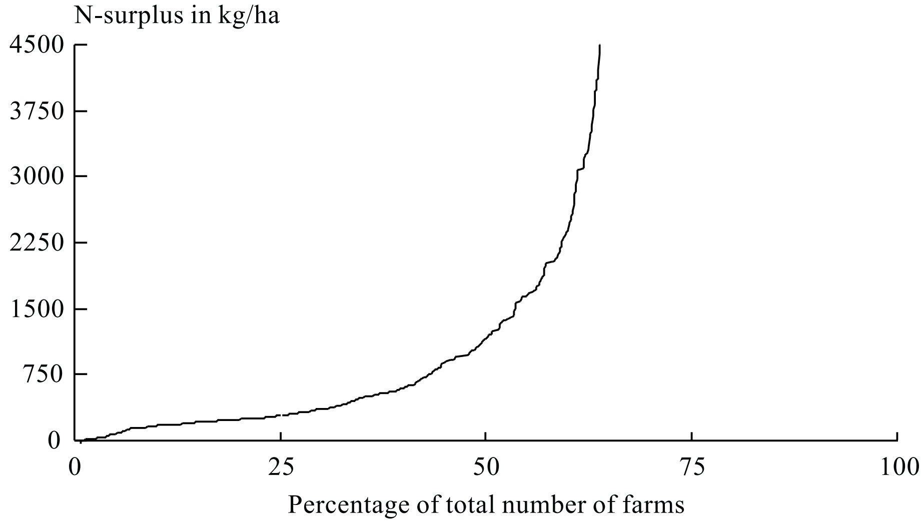

Figure 2.5 Nitrogen surplus of granivore farms across the EU in 1990/91 (farms ranked by nitrogen surplus)
Source: FADN-CCE-DG VI/A-3; adaptation LEI.

2.8 Concluding remarks

1. Animal density (in terms of number of livestock units per hectare of land) reflects the intensity of livestock production. Animal density at regional level in the EU exceeds 2 LU/ha in most of the Netherlands, part of Germany (some regions in Niedersachsen and Nordrhein-Westfalen), part of France (Bretagne), the northern part of Italy (Lombardy) and some parts of Spain (regions of Galicia and Cataluna). It is a useful indicator on the structure of farming. However it does not fully reflect nitrogen load and therefore only is partially linked with nitrogen pollution problems.
2. Nitrogen pollution problems are a major issue in the 'hot spots' of intensive livestock production, including the region of Flanders (Belgium), part of Germany (Niedersachsen and Nordrhein-Westfalen), Bretagne (France), large areas of the Netherlands, the northern part of Italy and the region of Cataluna (Spain). The share of pigs and poultry in the regional livestock population exceeds 50% in most of the regions with a high density of livestock population.
3. Livestock density needs to be considered at farm level in order to increase the understanding of options to reduce nitrogen pollution problems by changing farming practice. Density of livestock population is highest at holdings with intensive livestock production (mainly pigs and poultry). In the EU it ranges between around 1-2 LU/ha at drystock holdings with non-dairy cattle and dairy farms; in comparison it is around 20 LU/ha in the average for all granivore farms in the EU. Compared to cattle, pig production therefore may face more difficulties in reducing excess amounts of nitrogen from manure.
4. Countries like Belgium, Denmark, France and the Netherlands are large exporters of pigs and pigmeat. As a consequence, nitrogen excretion remains in the country resulting in an excess nitrogen load for the carrying capacity of the land.

5. Import of feed concentrates is an indicator to the nitrogen pollution problems from intensive livestock production. The equivalent of about 1.5 million tonnes of nitrogen from feed ingredients (exclusive of cereals) is imported on an annual basis from outside the EU by the Member States. Some 70% of the total protein requirements to feed pigs and poultry originate from outside the EU. About 80% of the soyabean products imported by EU Member States originate from outside the EU.
6. Nitrogen pollution problems arise when significant excesses of nutrients are applied on the land compared with the amount required for crop growth. Manure production is a major component in this respect. The amount of nitrogen from livestock production across Member States ranges from less than 50 kg N/ha (Greece, Spain, Italy, Portugal, Finland and Sweden) and over 200 kg N/ha (Belgium and the Netherlands). Nitrogen surpluses however reflect both input and output flows of nutrients. They are highest (over 100 kg N/ha) in Belgium, Denmark, large areas of Germany (e.g. Schleswig-Holstein, Niedersachsen, Nordrhein-Westfalen, Bayern), parts of Spain (Cataluna), France (Bretagne), as well as in Luxembourg and the Netherlands. Intensive pig and poultry units are major component in these regions.

3. Environmental requirements in policy and their impact on intensive livestock production

3.1 Introduction

The reduction of nitrogen pollution is a priority in European agriculture. Farmers must respond to constraints in nitrogen output. Member States of the EU generally design their policies by applying the Nitrates Directive. The objective of this chapter is to review current legislation by EU Member States to reduce nitrogen pollution problems. Firstly, measures taken by countries in response to the Nitrates Directive are reviewed, as well as their impacts on livestock production (Section 3.2). This chapter also briefly reviews other environmental policy objectives related to livestock production, which can impact intensive livestock production (section 3.3). Also, linkages are explored between CAP and its role in promoting less intensive production methods in the EU (section 3.4). Finally, environmental policies analysed in the subsequent part of this report are identified (section 3.5).

It is important to bear in mind the procedural differences between directives and regulations in the context of European policy. Both are the main legal instruments to implement EU policies. Directives inform Member States of goals and of a time frame for their achievement. The implementation of directives is left to Member States, thus allowing them to achieve the common goal in ways that recognize their national character. In comparison, Council Regulations are legal mechanisms establishing uniform laws across the EU. Directives are to a large extent used to the achievement of environmental quality objectives, whereas Council Regulations are generally applied in agricultural policy.

3.2 Directives to control nitrogen pollution

A brief outline of Directives to protect the European environment is provided in this section. Emphasis is given to Directives requiring major adjustments (e.g. curative measures such as storage and transport of manure, and preventive measures like adaptation of management practices) in intensive livestock production in order to reducing nitrogen pollution.

The Nitrates Directive

A Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources was issued by the Council in December 1991 (91/676/EEC) (Official Journal of the European Communities, 1991). This Directive is under the responsibility of the Directorate-General Environment, Nuclear Safety and Civil Protection (DG XI). Policies are being formulated in several Member States in order to reduce pollution of ground water (nitrates), surface water (eutrophication by excessive use of nitrogen and phosphate fertilizers) and the atmosphere (emissions of ammonia) (see also Rude and Frederiksen, 1994).

Directive 91/676 includes regulations on how to handle manure and fertilizers in zones which are identified to be vulnerable to the leaching of nitrate. A number of Member States have identified such zones. 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 ha. This standard should be met at farm level by the year 2003. Two four-years periods up to the year 2003 are identified in the Nitrates Directive, during which a gradual reduction in the level of application is allowed. By the end of the first period (which lasts from 1995 until 1999) a maximum of 210 kg of nitrogen from manure may be applied. The application of nitrogen from livestock manure is to be reduced further during the second four years period, until the level of 170 kg is achieved by the year 2003.

Codes of good agricultural practices were expected to be formulated by Member States before the end of 1993, in order for farmers to fulfil the objectives of the Nitrates Directive. The majority of the Member States have now completed this exercise. Such Codes should specify the following items (annex (ii) of the Directive):

- periods of the year when the application of fertilizer is inappropriate;
- the land application of fertilizer to steeply sloping ground;
- the land application of fertilizer near water courses;
- the capacity and construction of storage vessels for livestock manure;
- procedures for the land application, including rate and uniformity of spreading, of both chemical fertilizer and animal manure, that will maintain nutrient losses to water at an acceptable level.

In addition, Member States may also include in their Codes of good agricultural practices measures regarding (a) land use management, (b) the use of catch crops, (c) the establishment of fertilizer plans and keeping record on a farm-by-farm basis on fertilizer use, and (d) management of irrigation systems.

Member States shall also establish action programmes concerning designated vulnerable areas. The measures in the Action Programme must include rules relating to:

- periods when the land application of certain types of fertilizers is prohibited;
- the capacity of storage vessels for livestock manure;
- limitation of the land application of fertilizers, consistent with good agricultural practice and taking into account the characteristics of the concerned vulnerable zones (e.g. soil, climate, cropping practice).

Integrated Pollution Prevention and Control (IPPC)

A common position was adopted by the Council on 27 November 1995 with a view to adopt a Council Directive concerning integrated pollution prevention and control (Official Journal of the European Communities, 25.3.96) (96/C 87/02). The purpose of this Directive is to achieve integrated prevention and control of pollution arising from the activities listed in annex I of the Directive. It applies to certain installations of energy industries, production and processing of metals, mineral industry, chemical industry, waste management and other activities. Regarding agricultural activities the Directive is applicable to installations for the intensive rearing of poultry and pigs with more than (a) 40,000 places for poultry; (b) 2,000 places for production pigs (over 30 kg), or (c) 750 places for sows. This Directive lays down measures designed to reduce emissions in the air, water and land from the activities listed in annex I, including measures concerning waste, in order to achieve a high level of protection of the environment.

Environmental Impact Assessment Directive (EIA)

The European Commission recently presented a proposal for a Directive to amend Directive 85/337 (EEC) on the assessment of the effects of certain public and private projects on the environment. The amendments would considerably increase the number of impact assessments required compared with the 1985 Directive. The annex lists the projects for which an impact assessment is compulsory (annex I from the Directive) and those for which it is not compulsory. Certain criteria however must be respected if the Member State decides not to require an assessment. Regarding agriculture, annex I of the proposal for a Directive now includes facilities for the intensive rearing of poultry or pigs with more than 85,000 places for broilers; 60,000 places for hens; 3,000 places for production pigs (over 30 kg); or 900 places for sows. Annex II presently lists 50 types of projects in the areas of agriculture, forestry, aquaculture, extractive industries, energy, production and treatment of metals, mineral industries, chemicals, textiles, leather, wood, paper, rubber, infrastructure projects, tourism and entertainment. Annex II includes projects for: a) the restructuring of rural land holdings; b) the use of uncultivated land or semi-natural areas for intensive agricultural purposes; c) water management for agriculture, including irrigation and land drainage projects; d) initial afforestation and deforestation for the purposes of conversion to another type of land use; e) intensive livestock installations (not included in annex 1).

Proposal for a Framework Directive on Water Policy in the EU

The European Commission recently proposed to the Council and the European Parliament for a Framework Directive on Water Policy in the EU. According to the Communication (CEC, 1996) the Commission is considering that the Nitrates Directive and the proposed Integrated Pollution Prevention and Control Directive move into the Directive on Water Policy. The principles of European Community Water Policy are likely to be based on the following principles:

- high level of protection;
- precautionary principle;
- preventive action;
- damage to be rectified at source;
- polluter pays;
- integration;
- the use of available scientific and technical data;
- the variability of environmental conditions in the regions of the Community;
- costs/benefits;
- the economic and social development of the Community and the balanced development of its regions;

- international cooperation;
- subsidiarity.

The principles are also set out in Article 130R of the Treaty, requiring the integration of the environment into other community policies.

3.3 Policies implemented and their impact on intensive livestock production

In this section policies to address nitrates in ground water and surface water are briefly addressed. Emphasis is given to measures taken in Belgium, Denmark, Germany, France, the Netherlands and the United Kingdom. It indicates the diversity of the measures taken.

Belgium

Emphasis is given here to policies in Flanders since nitrogen pollution problems are more acute here than in the other regions. Most important nitrate policies in Flanders are part of the Manure Action Plan which was enforced by the end of 1995. Compulsory fertilizer balance sheets need to be kept in Flanders.

By the year 2002, standards on the application of nitrogen should not exceed 450 kg/ha for grassland and 275 kg/ha for the other crops grown, inclusive of nitrogen from organic and inorganic sources. This still exceeds standards on the application of nitrogen from organic sources, as formulated in the Nitrates Directive. There are strict rules regarding the disposal of excess amounts of livestock manure. As of 1999, rules on the disposal of manure depend on farm size. By that time, holdings with a livestock manure output which exceeds 10,000 kg are obliged to transport manure over long distances to regions with lower excess of manure.

The policy measures for the disposal of livestock manure makes a distinction between family livestock farms and other livestock farms. The policy was introduced mainly for social reasons, to maintain family livestock farming. The definition of family livestock farm is based on: a) farm management structure since the farmer must be the owner or tenant of the land; b) farm size (which should not exceed 1,800 pigs, 100 dairy cows or 300 other cows, 700 calves or 70,000 laying hens); c) sufficient land to dispose of 25% of the manure produced at the farm.

Agricultural holdings which do not comply with these conditions are requested to transport animal manure to regions without manure surpluses (so-called shortage regions) or to process the excess amount.

An assessment on the effectiveness of the socio-economic perspective of manure policies was made by Lauwers (1997). The results indicate the ineffectiveness of policies to regulate long-distance transport of manure. Policies implemented cause a less than optimal allocation of excess amounts of manure because livestock producers which meet the requirements for the definition of family livestock farms may dispose their excess manure at lower costs than the other farms. Compulsory processing of manure may be more effective although the amounts processed remain small due to the high costs involved.

Denmark

A standard on the application of nitrogen from livestock manure is being prepared in Denmark according to the Nitrates Directive. Such a standard is expected to be implemented without major difficulties as it is close to present regulations.

A Plan for Sustainable Agriculture was introduced in 1991, including regulations which allow for a better utilisation of livestock manure. In addition to utilisation standards, rules are also applied which prescribe that the amount of nitrogen applied at farm level should not exceed nitrogen requirements to grow the crops, depending on soil type, climatic conditions and expected yield. A farmer may comply with the rules by over-estimating its expected yield (Schou, 1997). Hence, the farmer will, in practice, be applying excess nitrogen compared with a realistic evaluation of probable yields. Detailed investigations are required to estimate the compliance by farmers with the rules. A revision of the former Action Plan is presently being debated.

Germany

The implementation of the Nitrates Directive is achieved in Germany by the Düngeverordnung, which was accepted by Parliament early 1996. Farmers can comply with the Directive by lowering the protein content in feedstuffs. Mineral balances must be assessed by holdings with farm size exceeding 10 ha and a supply of nitrogen from livestock manure above 80 kg of nitrogen per hectare. Nitrogen balances are required on an annual basis, whereas phosphate and potassium balances are required once every three years. These measures are aimed to stimulate farmers in their efforts to reduce mineral surpluses.

The impact of the Nitrates Directive on agricultural holdings in Germany were assessed by Schleef (1997). This analysis showed that approximately 25% of the group of farms comprising of pig, poultry and mixed farms are affected by the Nitrates Directive. In addition, almost 20% of the cattle farms also are affected by the Directive. Generally speaking, the reduction of gross margin and mineral surpluses following the requirements of the Directive are highest for pig, poultry and mixed farms. This analysis also indicates the Nitrates Directive may put increasing pressure on manure markets and on land utilisation.

The RAM-feeding Programme was developed by farmers and feed manufacturers. It is aimed at reducing phosphorus and nitrogen output from pig and poultry farms. It has proven effective and achieved the potential practical limits of reducing output of these nutrients. Excretion of nitrogen and phosphorous for finishing pigs can be reduced by 24% respectively 33%; for piglets by 10% respectively 25%; for turkeys by 8% respectively 35%; for broilers by 20% respectively 25% and layer flocks by 10% respectively 38% (Bohnenkemper, 1996). These percentage values are considered in the calculation of disposal area, if farmers agree with other minor points in the RAM-Feed-Contract. The RAM-Feeding Program is on a contractual basis and controlled by the regional agricultural chambers.

France

Nitrate policies in France have been based primarily on advisory campaigns, extension service and promotion of research projects. In addition, Codes of good agricultural practice have been drawn up. National policies on nitrates largely focus on advisory schemes. Nitrate policies in Bretagne are based on the Installations Classées pour la Protection de l'Environnement (Act on Classified Installations for Environmental Protection). Standards on the application of nitrogen in Bretagne presently only apply to new livestock breeding installations, but they will also apply to all holdings by the year 1999.

The Act on Classified Installations for Environmental Protection presently call for restrictions on the application and spreading of animal manure, and nitrogen balance sheets. The application of nitrogen from livestock manure should not exceed 170 kg per hectare as of the year 2003, according to the limits put in the Nitrates Directive.

CORPEN was established in 1984 to explore options of reducing water pollution from nitrates and phosphates, as well as pesticides. CORPEN (le Comité d'Orientation pour la Réduction de la Pollution des Eaux par les Nitrates, les phosphates et les produits phytosanitaires provenant des activités agricoles) also evaluated the excretion levels from pig units, which also resulted in new reference levels reflecting on-farm changes which have been achieved since the end of the 1980s. The impacts of nutritional management on the excreted nitrogen from pigs have been assessed by CORPEN (1996).

The Netherlands

The implementation in the Netherlands of the Nitrates Directive is part of the Integral Note on Manure and Ammonia Policy. To target the standards set out in this Directive, national government decided to use mineral accounting at farm level as a central policy instrument. The amount of nitrogen lost to the environment is considered to be a better indicator of environmental harm caused by fertilizers, rather than the total amount of nitrogen used.

As of 1998, a mineral declaration system is required for all intensive livestock holdings with animal density exceeding 2.5 LU/ha. On the basis of the 1995 census on livestock population and land utilisation, three-quarters of the dairy farms and nearly all granivore farms must make a mineral declaration system from 1998. These farmers should apply their manure in an environmentally sound manner. This system will be applicable to all livestock farms as of 2000, and to all agricultural holdings by 2002. Farmers are charged to pay a levy in case their so-called acceptable losses of nitrogen and phosphate exceed certain standards. A system of mineral bookkeeping is required as a tool to identify the mineral balances.

The United Kingdom

Control of nitrogen pollution is an important priority for the UK government which is supporting the EU Nitrates Directive assiduously. Therefore, legislation is driven by the Nitrates Directive primarily through the Code of Good Agricultural Practice (1991) which will become law. Through the Code, the Ministry of Agriculture, Fisheries and Food gives information on how to control pollution from animal waste and an average Biochemical Oxygen Demand

(BOD) that is likely from each source. The government offers equally all options of controlling excessive nitrate pollution and views as the responsibility of each producer to respond to the regulations using the option that he sees as most appropriate.

3.4 Agricultural policies will contribute to the achievement of less intensive production methods

The CAP is of major importance to the present state of agriculture. The original objectives CAP are specified in Article 39 of the Treaty of Rome, and were described as follows:

- to increase agricultural productivity;
- to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture;
- to stabilize markets;
- to ensure stability of supplies;
- to ensure that supplies reach consumers at reasonable prices.

The reform in 1992 of CAP was, among others, aimed to adjust agricultural policies and alter farming practice towards the adoption of less intensive production methods. Measures were adopted to reduce surplus production, reduce price support (together with more targeted direct income support), and improve environmental soundness of agricultural production. The most fundamental change of the CAP reform addressed cereals. The main objectives of the cereals reform are to improve market balance and the competitive position of the EU. The reform of this regime also aimed to increase the use of cereals in feed.

Consideration of environmental requirements are required to be observed by government policies beyond the direct issues dealt with in the Nitrates Directive. According to Article 130R (2) of the Treaty of the EU, 'environmental protection requirements must be integrated into the definition and implementation of other Community policies'. Environmental clauses presently are included in Council Regulations on arable crops, beef and sheep (Brouwer and Van Berkum, 1996).

In addition to the reform in 1992 of the arable crop regime, measures were also taken to the reform of animal products, including the beef and sheep regimes. The reform of the beef regime included a 15% reduction in the intervention price for beef from July 1993, in three steps, with compensation through direct headage payments which are subject to a maximum stocking rate (2 Livestock Units, LU, per hectare of forage crops by 1996). In addition, there are extra payments if a producer reduces the stocking rate below 1.4 LU per hectare of forage crops. Also, the sheep regime was reformed by putting individual limits of full ewe premium based on eligible claims made in 1991. Limits are put on the full ewe premiums to be paid per holding. Measures taken in CAP regarding stocking rates are not linked to nitrogen pollution problems directly, rather they are mainly directed to reduce the intensity of livestock production units. This however could diminish nitrogen pollution problems indirectly.

Brouwer and Van Berkum (1996) conclude that the extensification effects of the reform of beef and sheep regimes have been limited so far. Experiences in Member States indicate the relative unattractiveness of the beef premium to the farmer, hence livestock density has not been reduced. Any effects of the reform of the sheep regime on extensification might be limited because a large proportion of holdings remain eligible for full compensation.

The basic regulation for pig production is Council Regulation 2759/75, in which main mechanisms to support the market for pigs are outlined. It includes public support buying measures, private storage aids and export refunds. Price support given to intensive livestock production is negligible in the EU. Direct effects of price policies regarding pig production on the environment therefore are likely to be limited in that sector. Indirect effects of CAP reform on nitrogen pollution control however might be substantial following adjustment by nutritional management. Linkages between pig production and the reform of the cereal regime by adjustment of nutritional management will be further explored in chapter 5 of the report. Pigmeat is treated as a 'cereal-based' product, as there are close links between the cereals and pigmeat regimes.

Three scenarios of agricultural policy are explored in the remaining part of the report (chapters 5, 6 and 7) in order to assess the role of agricultural policy in nutritional management of European livestock production:

1. the period in 1988 before the reform of agricultural policies (*CAP-1988*);
2. the reform of agricultural policy in 1992. The situation of 1994/95 is considered (*CAP-1994*);
3. an additional reform which is projected to take place around the end of the century (*CAP-2000*).

More information on the scenarios of agricultural policy is provided in Appendix E of the report.

3.5 Environmental policies to be analysed

Two scenarios of environmental policy will be distinguished in chapter 7 of the report:

1. *Application standard*. The application of nitrogen from livestock manure should not exceed 170 kg of nitrogen per ha. This standard is one of the main elements of the Nitrates Directive, which should be met at farm level in zones vulnerable to the leaching of nitrates by the year 2003.
2. *Mineral balance*. This scenario is targeted on nutrient surpluses, rather than on the application of nitrogen from livestock manure. It is based on the mineral declaration system (mineralenaangiftesysteem, Minas) which is required in the Netherlands as of 1998 by all intensive livestock producers with animal density which exceeds 2.5 livestock units per ha.

3.6 Concluding remarks

1. The EU is putting into place environmental policies to control aqueous and gaseous pollution which affect intensive farming enterprises. Environmental requirements for intensive livestock production are formulated today in policies of EU Member States,

either in response to targets agreed at national level or in response to Directives with a time frame for their achievement. Policy responses for the reduction of nitrogen pollution problems in Europe are broader than the implementation by Member States of the Nitrates Directive. Integrated Pollution Prevention and Control needs to be considered in the future as well as initiatives from the European Commission on the Proposal for a Framework Directive on Water Policy in the EU. Solutions are being searched for by several countries in their efforts to reduce nitrogen pollution problems, focussing on the application of nutrients rather than considering the whole chain of input and output flows in intensive livestock production. Individual states may have their own legislation, but it is the EU legislation which is driving the environmental policy in the region as a whole.

2. Implementation of policies has not considered the whole chain of input and output flows. Policy responses to meet the requirements of the Nitrates Directive are at present targeted on detailed measures for the application of nitrogen from organic and inorganic sources, for the application of livestock manure and storage requirements. Special regulations may apply to designated zones, including water protection zones to safeguard drinking water resources and protect surface waters from eutrophication. Several Member States presently initiate efforts to keep records of nutrient flows across agriculture through nutrient balance sheets. Such individual legislation tackling the pollution problem at the source is resulting in an non-coherent approach leading to an incomplete application of the Nitrates Directive.
3. Compared to market and price policies on beef, dairy and cereals the direct impact of agricultural policy on pig production is limited. This is due to the limited price support under CAP provided to pig production. However there are tariffs on the import of pigmeat from outside the EU which is due to the price support given to cereal production. As a result of such tariffs, the import of pigs and pigmeat from outside the EU also is very limited. Such tariffs on the import of pigmeat do provide some incentive to increase pig production in the EU.

4. The influence of nutritional management on nitrogen output

4.1 The changing environment for feed formulation

The objective of the nutritional management of livestock is to produce high quality meat at an affordable price for the consumer. To achieve this objective the livestock producer has to breed and grow farm animals efficiently. The feed formulator supports the producer by providing diets balanced in nutritional components, such as, energy, protein (or more specifically, essential amino acids) and vitamins. These diets are made of available raw materials combined to meet the nutritional constraints at the lowest possible costs. The cheapest combinations have resulted in relatively high levels of dietary protein (of which nitrogen is a major component), in order to assure, at least, minimum levels of all essential amino acids for effective breeding and efficient growth. A considerable excess of nitrogen has resulted which has been simply excreted. This was a satisfactory solution whilst the disposal of nitrogen was not considered a problem. Today, the equation has changed. There is an environmental and economic cost in the disposal of surplus nitrogen. Now, the objective is to grow an animal using feed more closely aligned to its requirements in order to achieve its production targets.

Knowledge is continually being improved both in the nutritional requirements of farm animals and also the availability of nutrients from different feedstuffs. The nutritional requirement of animals is founded on the energy and amino acid relationships. For pigs, feed formulation will be primarily based on the ratio of energy to lysine (usually the first amino acid to be limiting) whereas, for poultry, it is the ratio of energy to methionine (as the first limiting amino acid). Then, the requirements for other dietary components (for example, other essential amino acids, fibre, vitamins) are incorporated in the feed formula. The target is to achieve a highly digestible feed in which as few nutritional components as possible are in excess, given typically available feedstuffs. The nutritional requirements and efficiency of nitrogen retention will vary for each species of animal and its stage of production.

For the feedstuffs and feed supplements (such as wheat, barley, maize, peas, rapeseed meal, fishmeal, crystalline amino acids and vitamins), different materials have different combinations of the available nutrients described above.

Finally, the costs vary between the feedstuffs, therefore it is the role of the feed formulator to provide a diet which fulfils nutritional and financial objectives. The effects of changes in the relative costs of cereal feedstuffs through CAP reform and the need to reduce nitrogenous waste from livestock enterprises in feed formulations will be evaluated in the following chapters. It forms the basis for the argument that nutritional management of excess nitrogen production from livestock enterprises is a highly competitive method of reducing overall nitrogen surplus in certain European regions described previously (table 2.14), and later in this chapter with respect to pigs and poultry production.

4.2 The nutritional strategy for reducing nitrogenous waste from livestock enterprises

Excretion is a necessary by-product of digestive and metabolic processes in any animal.

Feedstuffs are not completely digested, for example, due to the presence of fibre and tannins, as in peas. Availability of amino acids in feedstuffs can vary between 58 and 98% depending on feedstuffs, although a typical value would be around 85% (Dale, 1996). The level of availability of a feedstuff may be affected positively or negatively by external processing factors, such as micronisation and enzymes. It is noteworthy that crystalline amino acids are virtually 100% digestible.

All animals also turn-over the materials of which they are composed. This is the maintenance demand which is over and above any requirement for growth or reproduction. Consequently energy and amino acids are continually required and the products of their metabolic processes excreted. Hence, a basal level of excretion is not avoidable. It is an object of present-day research of the nutrient availability of raw materials and the nutrient requirements of livestock to move towards a practical minimum level.

Several feed related strategies are available to reduce the potential reduction in nitrogen surpluses (Williams, 1995). They include the use of feed supplements (such as enzymes, amino acids and growth promoters) and feeding systems (such as separate sex feeding, phase feeding, reduced dietary protein through precision in feed formulation and the use of highly digestible raw materials). Not all are cumulative, but the two most powerful tools, phase feeding and low protein diets complement each other.

Phase feeding and dietary protein restriction for pigs

The energy and protein requirements of an animal change each day as it grows. Therefore, an ideal feed should adopt its composition in line with the animal's requirements in order to control tissue deposition and to obtain a carcass of given quality. In practice this is generally not the case. Two phases (i.e. two diets) for pigs from 25 to 110 kg live weight theoretically reduces nitrogen output by up to 20% in comparison with a single phase (one diet; Lenis, 1989; Coppoolse et al., 1990; Gatel and Grosjean, 1992; Henry and Dourmad, 1993). Chauvel and Granier (1996) reduced nitrogen excretion by a further 9% through a multiphase versus a two phase system. However, a multiphase system requires sophisticated and expensive equipment for dry feeding and is best placed in very large scale production enterprises. In practical terms, three phases may be the most feasible option for growing pigs.

The system of phase feeding is illustrated in figure 4.1. Multi-phase feeding could adjust nutrient supply to bring it closer to the needs of the animal. Excess supply of nitrogen could be reduced by adjusting the supply of dietary nitrogen according to the weight of the animal.

The greatest reduction in nitrogen excretion may be offered through the use of low protein diets. Diets formulated for all digestible essential amino acids result in pig performance at least equivalent to higher protein diets, but with reduced nitrogen output (Koch, 1990; Kies et al., 1992).

At present, the lower limit may be between 13 to 14% for growing/finishing pigs in commercial conditions given constraints in the nutrient availability of the raw materials.

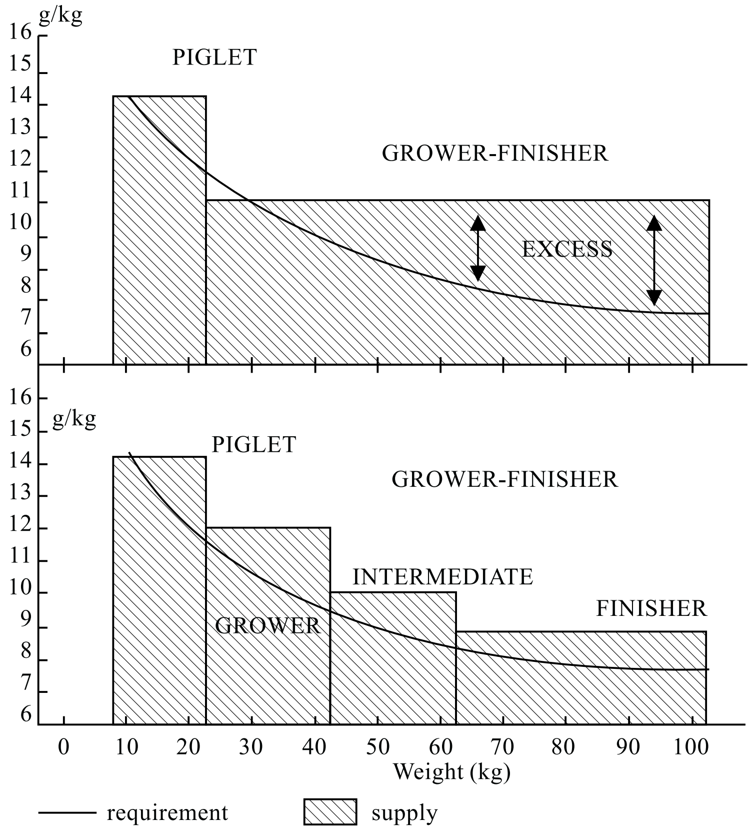

Figure 4.1 Lysine supply and requirement in a 2-feed and a 4-feed programme for pigs from birth to slaughter

Figure 4.2 also includes three diets which are supplemented by pure amino acids.

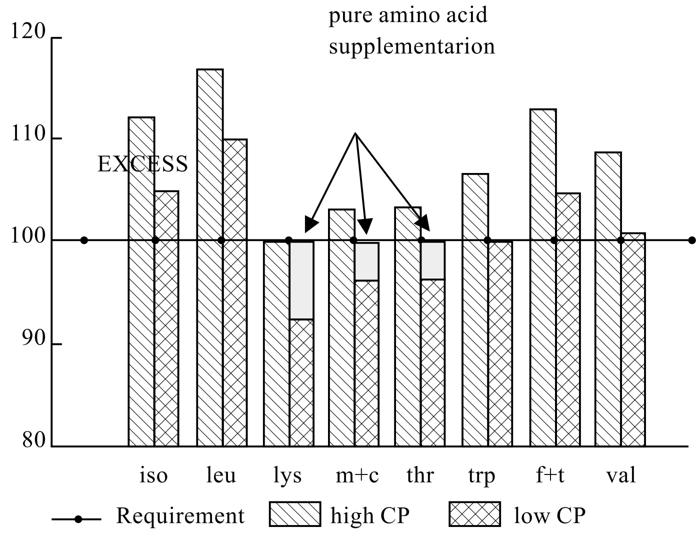

Figure 4.2 Example of the content of amino acids coming from feedstuffs in compound feed (%), comparing the case with and without crystalline amino acids

Schutte and Tamminga (1992) indicated that the optimal level of crude protein is 13.7% and 16% for gestating and lactating sows respectively. Lower protein diets are feasible, but require careful cost-benefit analysis to justify their use.

Overall, Dourmad et al. (1995) suggested that a reduction of 20 to 25% in nitrogen excretion may be the realistic commercial limit due to price rises in the lower protein diets, but they did not account for the macroeconomic effects of CAP reform on cereal prices and least-cost formulation. The role of agricultural policy in nutritional management is explored in chapter 5. A combination of three phase feeding and lower protein diets for pigs between 25 and 110 kg live weight indicated that an overall 10% drop in nitrogen output would result from each 1% reduction in dietary protein (Mongé et al., 1997). The potential for reducing nitrogen excretion without compromising performance has been calculated by several authors. Table 4.1 shows crude protein levels for various animal types in the Netherlands. In this table, *CAP-1994* figures on finishing pigs and broilers reflect average conditions and do not distinguish among weight levels of livestock. Similar figures for pigs in Bretagne are presented in table 4.2. A distinction is made between different types of nutritional management measures, and described in CORPEN (1996). Differences among the Netherlands and Bretagne are substantial and arise because of feeding regimes and dietary protein restrictions used.

Table 4.1 Crude protein levels in compound feed (%) in the Netherlands

Type of feed	CAP-1994	CAP-2000		
Nutritional management		current	controlled	potential
Growing pigs				
- 20 - 40 kg	17.4	17.5	16.0	14.0
- 40 - 70 kg	17.4	16.3	14.5	13.5
- 70 - 105 kg	17.4	16.0	14.0	12.5
Pregnant sows	16.2	13.7	11.8	10.5
Lactating sows	16.2	16.0	14.0	13.0
Layer feed	17.8	17.0	15.0	13.1
Broilers				
- 0-14 days	22.9	22.0	21.0	19.0
- 14-38 days	22.9	21.7	20.0	18.0
- 38-44 days	22.9	21.4	19.0	17.0

Source: Van Eerdt, 1996; Klein et al., 1996; Schutte and Tamminga 1992; Beukeboom et al., 1991.

Potential nutritional management would also require the commercial availability of the crystalline amino acids valine, isoleucine and histidine, which are not yet today widely marketed. According to the opinion of experts in nutritional management for pigs, the situation is unlikely to change in the near future. Nutritional management may technically go lower than the crude protein levels presented in table 4.1. Limitations however arise due to economic and animal metabolic factors. Major changes in market conditions would be required before new free amino acids, such as valine etcetera, would become commercially available.

Table 4.2 Crude protein levels (in %) in compound feed for pigs in Bretagne

Type of feed	CAP-1994	CAP-2000	
		controlled	potential
Finishing pigs < 60 kg	17.5	16.5	15.5
Finishing pigs > 60 kg	17.5	15.0	13.0
Piglets	19.2	18.3	17.4
Pregnant sows	16.5	14.0	12.0
Lactating sows	16.5	16.5	16.0

Source: CORPEN, 1996.

Phase feeding and dietary protein restriction for poultry

Nutritional management of poultry nitrogenous output is also most responsive to the same two tools: phase feeding and precise formulation of diets. Broiler feed may be provided in three phases during the growing period. Again this would be most effective if done in combination with lower protein diets. As with pigs, practical constraints in the nutrient availability of the raw materials produces the lower limit (20.5% protein). Diets of 18% crude protein would be possible if valine and arginine were commercially available for poultry feed (Schutte and Tamminga, 1992). Therefore, a potential reduction of nitrogen excretion may be calculated (table 4.3).

Further crude protein decrease requires the commercial availability of other crystalline amino acids in addition to the four ones which are typically used, lysine, methionine, threonine and tryptophan. Protein levels may potentially be further reduced in case crystalline forms of the amino acids (e.g. valine, isoleucine and histidine) become available on the livestock market (Coppoolse et al., 1990). In that case, feed to grow broilers would require the commercial availability of crystalline amino acids, valine and arginine. According to the opinion of experts in nutritional management, the situation is unlikely to change in the near future.

Breeding stock (layers) may reduce nitrogen output by lowering dietary protein from a typical 17% to 15% (table 4.1). Further reduction is dependent on similar requirements of additional commercially available crystalline amino acids.

4.3 The potential of nutritional management on reducing nitrogen output from pigs and poultry

Several investigations have been made in the Netherlands regarding the potential reduction of nitrogenous excretion in future. Two methods of nutritional management are derived from Schutte and Tamminga (1992) and Beukeboom et al. (1991). Methods used are described below and form the basis of the analyses in chapters 5, 6 and 7.

The present report considers four different excretion levels of livestock (table 4.3). Crude protein levels in compound feeds which would achieve excretion levels mentioned in table 4.3 are presented in table 4.1. *Potential nutritional management* includes amino acids such as isoleucine, valine and histidine (Beukeboom et al., 1991). The case of *potential nutritional management* is theoretical but not yet applicable.

Tables 4.3 and 4.4 indicate a big potential to reduce nitrogen excretion from pigs and poultry by implementing adequate feeding programs. Several regions, which are most vulnerable to nitrogen pollution problems, are starting to undertake nutritional measures to reduce nitrogen output. Several of these regions remain have not developed as far as current nutritional management in the Netherlands, as described in tables 4.1 and 4.3. The initial policy goals in the Netherlands were targeted primarily at reducing phosphate levels by a range of measures. More recently they also aim to further reduce nitrogen pollution as well. The Netherlands have advanced well in taking nutritional measures based on phosphate which have reduced nitrogen output to some extent. Such measures were taken in response to policies to reduce excess amounts of manure supplied by intensive livestock production units.

Table 4.3 Nitrogen excretion from livestock (kg N per animal per year) comparing CAP-1994 and CAP-2000 showing the influence of three levels of nutritional management in the Netherlands

Type of feed	CAP-1994	CAP-2000		
Nutritional management		current	controlled	potential
Cows	143.4	143.4	143.4	143.4
Beef cattle	64.6	64.6	64.6	64.6
Beef calves	10.6	10.6	10.6	10.6
Sows	31.4	25.1	23.2	22.5
Finishing pigs	14.5	12.7	10.9	9.8
Laying hens	0.81	0.81	0.59	0.53
Broilers	0.63	0.60	0.53	0.43

Source: Van Eerdt, 1996; Klein et al., 1996; Schutte and Tamminga, 1992; Beukeboom et al., 1991.

Table 4.4 Nitrogen excretion from livestock (kg N per animal per year) comparing CAP-1994 and CAP-2000 showing the influence of three levels of nutritional management in Bretagne

Type of feed	CAP-1994	CAP-2000		
Nutritional management		current	controlled	potential
Cows	143.4	143.4	143.4	143.4
Beef cattle	64.6	64.6	64.6	64.6
Beef calves	10.6	10.6	10.6	10.6
Sows	35.5 a)	32.4 a)	29.0 a)	23.2 a)
Finishing pigs	14.0 a)	13.0 a)	12.0 a)	9.9 a)
Laying hens	0.81	0.81	0.59	0.53
Broilers	0.63	0.60	0.53	0.43

a) CORPEN (1996).
Source: Van Eerdt, 1996; Klein et al., 1996; Schutte and Tamminga, 1992; Beukeboom et al., 1991.

Large differences prevail between the Netherlands and Bretagne in terms of the excess amounts of nitrogen produced. This will be further explored in chapter 7 of the report. Both regions have a high concentration of intensive livestock production. However, excess amounts of nitrogen from manure supplied at regional level in the Netherlands exceed the amounts in Bretagne (see also chapter 7). Bretagne could be seen as a region which might be more representative to other regions in Europe having high levels of nitrogen surpluses.

4.4 Nutritional management strategies to be analysed

Three scenarios of nutritional management are explored in the remaining part of the report in order to assess the economic and environmental benefits of reducing nitrogen pollution by nutritional management:

1. *Current nutritional management*. This scenario is based on least-cost formulation of diets using feedstuffs and feed supplements available to commercial companies. Its main objective is to provide feed for livestock which assures efficient performance in terms of feed:gain ratio and growth rate for meat animals. It ensures that the minimum nutritional requirements of animals are met at minimum cost which may be at the expense of the provision of excess nutrients, such as total dietary protein level. Hence, it ignores nitrogen output.
2. *Controlled nutritional management*. This scenario assumes that the reduction of nitrogen output is now also taken into account in feed formulation. It ensures that nitrogen output is reduced using commercially-available feedstuffs and feed supplements. Feed prices may differ from *current nutritional management* as dietary protein level is likely to be reduced to a technically proven limit which does not compromise animal performance.
3. *Potential nutritional management*. This scenario formulates feed according to scientifically established nutrient requirements of the animal. As a consequence, dietary protein levels will be very low and nitrogen waste minimized. Tools to realise this option are available (including supplementary amino acids such as histidine, isoleucine, leucine, arginine and valine), but not yet on large commercial scale. Hence, compared with the other scenarios, the feed price today will be high. Increased commercial demand for such tools may make them economical in the future.

4.5 Concluding remarks

1. Excretion is a necessary by-product of digestive and metabolic processes by animals. Nitrogen excretion is high because nitrogen is fed far above requirements in present least-cost formulated feed. It may be reduced by nutritional management systems: phase feeding and balanced amino acid levels in the diet. Feed strategies of pigs and poultry could largely contribute to reduce nitrogen surpluses, including the use of feed supplements (e.g. enzymes, amino acids and growth promoters) and the modification of feeding systems (e.g. phase feeding, reduced dietary protein through precision in feed formulation).

2. *Controlled nutritional management* gives a 20 to 25% reduction in nitrogen excretion in pigs and 15 to 35% reduction in broilers respectively. *Potential nutritional management* could further reduce nitrogen excretion.
3. Several regions of intensive livestock production have started to undertake nutritional measures to reduce nitrogen excretion. Nutritional measures taken so far in the Netherlands may have reduced nitrogen output to a larger extent than in other regions with nitrogen excess, such as Bretagne. The Netherlands have been the first EU country to take nutritional measures based on phosphate levels, which have also reduced nitrogen output to some extent. Elsewhere, the measures recently initiated in Bretagne have been based also on nitrogen output and may be more representative of the approach most suitable for other European regions having nitrogen surpluses.

5. CAP reform facilitates nitrogen pollution control

5.1 Introduction

The 1992 reform of CAP largely affected cereal prices and subsequently also contributed to price reductions of compound feed raw materials. Least cost formulation technique is commonly used in the compound feed industry, and a reduction of cereal prices therefore results into a modification of the composition of compound feed. In this chapter an assessment is made of the extent to which the CAP reform facilitates nutritional management by lowering protein content, and subsequently contributes to a cost-effective reduction of nitrogen pollution problems from European livestock production systems. Focus is on nutritional management of pigs and poultry, because of the major adjustments required in these sectors to meeting nitrogen pollution control measures.

The analysis is based on the Cereal and Compound Feed Market Model (CCM) of LEI. CCM is a regionalized multi-commodity model of cereals and compound feed raw materials. The model only covers the original 12 Member States of the EU (Blom, 1995). The three Member States which only entered the EU in 1995 (Austria, Finland and Sweden) are not yet included in this model. A more detailed description of the model is given in Appendix A of the report. The Appendix gives more information of the data input into the model so that the output can be evaluated.

A distinction is made into six policy alternatives. These policies distinguish between three stages of agricultural policy and two types of nutritional management, described in the previous chapters. The assessments include a comparison of conditions before the reform in 1992 of CAP (*CAP-1988*), with the period afterwards (*CAP-1994*) and a future scenario on agricultural policy (*CAP-2000*) (see also section 3.4 with background information on the policy scenarios). Also, a distinction is made here into two types of nutritional management, including *current nutritional management* and *controlled nutritional management*. Not included in this exercise is the scenario which is based on *potential nutritional management*, primarily because a wide application of such relatively low protein levels presently is not very realistic for the EU. A more detailed description of scenarios used is provided in Appendix E of the report.

Section 5.2 provides some detailed information regarding the feed consumption in the EU. A distinction is made between the on-farm use of grain, the need for supplementary protein concentrate and the use of compound feed. The impact of CAP reform measures on the compound feed market is assessed in section 5.3, and their implications for nutritional management are explored (section 5.4). Some concluding remarks are presented in section 5.5.

5.2 Feed consumption by pigs and poultry

The total feed requirements of pigs and poultry in the EU are estimated at about 109 million tonnes (table 5.1)[1] . Only figures at national level are given of some important meat producers, as well as the total of the EU. The on-farm use of cereals differs widely among countries. The on-farm use of cereals to feed pigs and poultry is negligible in the Netherlands. In comparison, in Germany more than 60% of the requirements to feed pigs comprises of direct on-farm use of cereals. At EU level the compound feed for pigs count for about 55% of the total feed consumption and the on-farm use of cereals count for about 45%. In the poultry sector the on-farm use of cereals is negligible.

Table 5.1 Feed consumption by pigs and poultry for relevant countries in EU-15 (in million tonnes, 1994)

	NL	BLEU	France	Germany	Denmark	Spain	EU-15
PIGS							
Compound feed	7.8	3.0	6.4	6.3	3.4	5.9	41.7
On-farm use of cereals	0	1.7	3.5	10.4	3.4	4.2	32.4
Total	7.8	4.7	9.9	16.7	6.8	10.0	74.1
POULTRY							
Compound feed	3.4	1.3	8.4	4.1	0.6	4.3	33.7
On-farm use of cereals	0	0.1	0	0.1	0.1	0	1.3
Total	3.4	1.4	8.4	4.2	0.7	4.3	35.0

Source: FEFAC, Eurostat, National statistics and calculations LEI.

The CCM model only covers feed produced by compounders, including concentrates required to supplement the on-farm use of cereals. Protein concentrate is one of the nine compound feeds in the linear programming model. This of course does not apply to those regions where the on-farm use of cereals is of negligible importance.

The method used to estimate the required amount of concentrates is to calculate the conversion rate of animal production (slaughter weight) in a region where the on-farm use of cereals is negligible (i.e. the Netherlands). This conversion rate is defined by the ratio between the production of compound feed and animal production. Total feed requirements are then calculated with this conversion rate and regional livestock production. A large number of technical conditions are considered to remain unchanged. A balance between the total amount of feed required and the compound feed production is achieved by the on-farm use of cereals. Results presented in this chapter are compared with the statistical information from Eurostat.

[1] The assessment of feed requirements by pigs and poultry is based on total production of meat and eggs in the EU, and the input-output conversion rates of the Dutch conditions. The compound feed consumption is based on FEFAC (Agra Europe, 1996) and is assumed to be inclusive of the amount of concentrate. The remaining parts of the feed requirements are assumed to originate from the on-farm use of grain.

Data from Eurostat also include the total on-farm use of cereals, including feed for cattle. Assumptions were made regarding protein supplements to on-farm use of cereals: in order to meet protein requirements of livestock, three kg of cereals require one kg of protein.

A detailed investigation of the on-farm use of cereals is out of the scope of this report. Some remarks are only made here. A comparison can be made between the performance data presented here with the figures from 1988, published in Blom (1995). The calculated input-output whole herd conversion rate of the Netherlands (without on-farm use of cereals) equals 4.6 kg feed/kg of pig meat, 2.6 kg feed/kg of poultry meat and 3.1 kg feed per kg of eggs. In comparison to the figures for the year 1988 the conversion rate of pork is worse and improved for poultry meat and for eggs. The expected trend of improved feed conversion rates is only verified for poultry production. The export levels of piglets, as well as the export of compound feed could both affect the feed conversion rate of pork. For example when many piglets are exported to other countries, the whole herd conversion rate will be influenced negatively due to the relatively large number of sows compared with the number of pigs finished in the country of origin.

Based on this method the total need for protein-concentrates for pigs is assessed at a level of about 9.0 million tonnes (situation in 1990) and 9.8 million tonnes (situation in 1994). The increase between 1988 and 1994 was some 20%. The need for protein-concentrates in the pig sector has been rising due to the increase of the on-farm use of cereals. The need for protein-concentrate in the poultry sector is negligible as is shown in table 5.1. The on-farm use of cereals for pigs is of no importance in the Netherlands and in Portugal.

Compound feed production

Total compound feed production in the EU is about 120 million tonnes (situation in 1995) (table 5.2). Approximately a third is for pigs, and the share of poultry feed is close to 30%. The remaining 40% is to feed cattle and other animals.

Austria, Finland and Sweden have a share of less than 4% in total compound feed production in the EU. In these countries around 1.2 million tonnes is used to feed pigs, and 1.1 million tonnes is provided for poultry. Calculations of the CCM model are limited to the EU-12 Member States. In practical terms the overall result is not influenced significantly as the new member states have a limited share of the compound feed market.

With the help of statistical information from different countries the compound feed production is subdivided to regions and different animal types. For each region 9 compound feed quantities are estimated with each a specific feed formulation.

Austria, Sweden and Finland

The total feed consumption in 1994 of intensive livestock production in Austria, Sweden and Finland is estimated to be 5.7 million tonnes. Almost half of it is accounted for by Austria. In comparison, Sweden accounts for about one third and Finland for about 20%. Total feed requirements to grow pigs are estimated to be 4.3 million tonnes; the remaining 1.4 million tonnes is mainly to feed poultry. The compound feed production for pigs and poultry in these three countries is 2.3 million tonnes of which 1.2 million tonnes is fed to pigs and 1.1 million tonnes is poultry feed. In 1995 the compound feed production of Finland increased by about 9% compared with 1994. However, feed production in Austria fell during that year by about 8%. In Sweden pig feed production was slightly reduced, and the production of poultry feed slightly increased over the same period.

Table 5.2 Compound feed production (exclusive of milk replacers) in 1990 and 1995 by Member State (million tonnes)

Member State	1990	1995	Relative change (%)
Belgium and Luxemburg	5.4	5.7	+6
Denmark	4.1	5.6	+37
Germany a)	16.5	18.9	+15
Greece	2.8	2.8	0
Spain	11.6	15.1	+30
France	17.4	21.1	+21
Ireland	2.4	3.3	+38
Italy	12.1	11.8	-2
The Netherlands	15.5	15.6	+1
Portugal	3.9	3.9	0
United Kingdom	11.2	11.8	+5
Austria	1.1 b)	1.0	-9
Finland	1.1 b)	1.2	+9
Sweden	2.3 b)	2.3	0
EU-12	102.9	115.8	+13
EU-15		120.1	

a) Germany 1990 is exclusive of the former GDR, 1995 is inclusive of the former GDR; b) data for the year 1994.
Source: FEFAC.

About 3.4 million tonnes is provided by on-farm feeding. This is based on the assumption of the gap between total feed consumption and compound feed production to be filled by the on-farm use of cereals. It implies that the on-farm use of cereals is a large share of total feed consumption. Austria has the highest share of on-farm use of cereals (75%). It is lowest in Sweden (41%). Finland is in between with a level of 55%. Similar to the EU-12, the major part of direct feed cereals are fed to pigs in these three countries.

Self-sufficiency rates of feed for the year 1995/96 are assessed to be 71% in the EU (Agra Europe, 1996). This figure implies that 71% of total feed consumption originates from internal production. The remaining 29% has to be imported from outside the EU. The self-sufficiency of Austria, Sweden and Finland together is 87%, while this figure for the EU-12 is calculated at 70%. Soyabean meal, citrus pulp, molasses and fish and meat meal are mostly imported by the three new Member States.

5.3 Impact of the reform of the arable crop regime on the compound feed market in the European Union

In this section the results of the agricultural policy case studies: CAP-1988, CAP-1994 and CAP-2000 (see also section 3.4) are presented. Firstly specific information is given regarding cereal prices, prices of the important (non-cereal) raw materials and the use of these raw materials in the EU-12. Prices and composition of compound feed are provided under the different agricultural policies and alternative feeding regimes.

Raw material prices

Some background information regarding raw material prices is given in this section. Further details are presented in Appendix A of the report. Cereal prices are based on the intervention price and are calculated with the CCM-model (module 1). The intervention prices (ecu/tonne) are presented below (and are exclusive of monthly increase of intervention and threshold prices):

	CAP-1988	CAP-1994	CAP-2000
Soft wheat	158.44	108.00	119.19
Feed wheat, feed barley	150.52	108.00	119.19

Source: Agra Europe, 1995.

In 1990/91 (*CAP-1988*) and 1994/95 (*CAP-1994*) the ecu-prices incorporate the 'switch over' coefficient. The system changed afterwards and the switch over coefficient was abolished on February 1, 1995. As a consequence the green exchange rate was reduced by approximately 20%. To compensate for this decrease in cereal prices in national currencies, it was decided to increase the intervention prices in ecu by about 20% (the so-called switch over coefficient). The original intervention price of 100 ecu/tonne has been increased to 119.19 ecu/tonne in 1995/96. The third agricultural policy change (*CAP-2000*) assumes a 10% lower intervention price (see section 3.4). This is equivalent to an intervention level of 107.27 ecu/tonne. The intervention prices in the *CAP-2000* scenario are based on current exchange rates. Table 5.3a and 5.3b show indices on cereal prices for some regions in the EU.

The regional market price is made specific for each region by summing up the intervention price and the region and cereal specific deviation of the intervention price and the market price. The historical difference between intervention price and market price are used in the CAP-2000 scenario. A transformation of ecu- prices to national currency prices is made because national prices are used in the feed formulation. Exchange rates for the year 1996 are used in the *CAP-2000* scenario.

Cereal market prices in the northern and southern regions of the EU showed different trends during the early 1990s. Especially during the period between 1990/91 and 1994/95 the cereal prices (in national currencies) showed a decreasing trend in the northern part of the EU.

Cereal prices however increased during the same period in countries such as Spain and Italy. Besides the conditions of the cereal market, this could partly be explained by the changes in the green exchange rates. The devaluation of the Spanish peseta led to higher prices in national currency, as is shown in table 5.3a and table 5.3b.

Table 5.3a Cereal price indices in some regions of the EU (CAP-1988 = 100) a)

Region	Feed wheat			Feed barley		
	CAP-1988	CAP-1994	CAP-2000	CAP-1988	CAP-1994	CAP-2000
Belgium and Luxembourg	100	78	59	100	80	57
Denmark	100	74	61	100	76	59
France north-west	100	75	59	100	79	58
Spain north-east	100	114	78	100	107	74
The Netherlands	100	76	58	100	77	57

a) Based on national currency.
Source: CCM - model.

Table 5.3b Prices of maize in some regions of the EU (CAP-1988 = 100) a)

Region	CAP-1998	CAP-1994	CAP-2000
Belgium and Luxembourg	100	78	56
Denmark	100	82	60
France north-west	100	79	57
Spain north-east	100	107	74
The Netherlands	100	78	57

a) Based on national currency.
Source: CCM-model.

The initial prices of the important (non-cereal) raw materials such as soyabean meal, maize gluten feed, tapioca and brans are used to initiate linear programming. After the first iteration of the linear programming new prices are calculated on the basis of supply and demand for such raw materials. The supply of the important compound feed raw materials is described by 'net excess supply' functions. The price elasticity of the 'net excess supply' function is, among other causes, determined by the share of the EU compound feed industry in the total demand for a raw material. This could be clarified by the two following examples. First, the EU has a relatively small share in world demand for soya, which implies that the impact of changes in the demand in the EU on the price of soya is limited. The EU however accounts for approximately 40% of global trade in soya. On the other hand the price of a product with a high share of the EU in the total demand (i.e. tapioca or maize gluten feed) will be stronger influenced by a changed demand of the EU. More detailed figures on the supply and demand balances are given in Blom (1995, pp. 70-76). The initial prices are based on statistical information of wholesale retailers prices in The Netherlands (see Appendix A of the report). For the purpose of our modelling it was assumed this was also applicable to the other Member States of the EU.

Price variations of important raw materials depend on demand and supply. Following *CAP-2000* (with relatively low prices of cereals), the demand for energy rich feedstuffs will be lowest. Consequently a price adjustment will take place. Table 5.4 shows the change in resulting prices for soyabean meal and tapioca under the various agricultural policies.

Table 5.4 Price-indices of two types of raw material in 5 regions of the EU (CAP-1988 = 100) a)

Region	Soyabean meal			Tapioca		
	CAP-1988	CAP-1994	CAP-2000	CAP-1988	CAP-1994	CAP-2000
Belgium and Luxembourg	100	88	81	100	77	60
Denmark	100	91	83	100	81	64
France north-west	100	91	82	100	79	61
Spain north-east	100	118	109	100	105	85
The Netherlands	100	89	82	100	76	57

a) Based on national prices.
Source: CCM-model.

Compared to *CAP-1988*, prices of soyabean meal and of tapioca generally show a downward trend under *CAP-1994* and *CAP-2000*. In Spain prices first increase but following *CAP-2000* show a decreasing trend as cereal prices in the north-eastern part of Spain. The price decrease of protein concentrates, such as soyabean meal, is lower than the decrease of an energy provider. Tapioca price in *CAP-2000* follows the trend of cereal prices. The CCM-model (see Appendix A of the report) shows that estimated prices of soya are a little higher under *CAP-1988* and could consequently lead to a minor underestimation of the protein content of compound feed.

Price and composition of compound feed

Table 5.5 shows the results of three different scenarios of agricultural policy. The impact of the agricultural policy on the total compound feed production (including cattle, pigs and poultry compound feed) is presented.

The share of cereals in total compound feed is assessed to be 33.9% in *CAP-1988*, and increases to almost 40% in *CAP-1994*. This exceeds figures published by the statistical yearbook of FEFAC (FEFAC, 1995). Based on FEFAC cereals account for 32.5% in 1990, 31.4% in 1991, 31.6% in 1992 and 31.9% in 1993. These figures are inclusive of crude protein concentrates. The Commission (1995) provides a cereal content of 30.7% for 1994 but it is not clear how this figure was calculated.

The method used to calculate cereal prices could explain such differences. The model calculations are based on a fixed deviation from the intervention price and do not take into account any specific market influences within a certain year. The model focuses on the medium-term impacts of policy changes and changes in market conditions and it is not intended to evaluate inter-annual price fluctuations in response to short-term market fluctuations.

Table 5.5 Price and composition of total compound feed in the EU-12 under three different scenarios of agricultural policy

	CAP-1998	CAP-1994	CAP-2000
Compound feed production (million tonnes) a)	102.9	113.1	113.1
Composition (% of total)			
- cereals	33.9	39.3	49.1
- soyabean meal	16.5	16.1	13.1
Protein content			
- in 1,000 tonnes	21,255	22,718	20,695
- in % of total	20.7	20.1	18.3
Total costs of compound feed at raw material level (in million ecu)	16,775	16,424	13,832
Average price (ecu/tonne)	163	145	122

a) EU-12 is exclusive of the former GDR.
Source: CCM-model.

CAP-2000 contributes to a reduction of cereal prices and subsequently provides an incentive to increase the share of cereals in compound feed to almost 50%. The total costs of compound feed (raw material level) are 16,775 million ecu under *CAP-1988* and 16,424 million ecu under the *CAP-1994*. The total compound feed production turnover in the EU-12 (including East Germany) was about 26,000 million ecu in 1994 (FEFAC, 1995). Total raw material costs therefore account for about two thirds of the total production costs of compound feed in the EU. Under *CAP-2000*, the total costs of compound feed on raw material level will be reduced by some 16% compared with *CAP-1994*.

The 1992 reform of CAP induced a reduction of cereal prices, compared to the stabiliser policy during the beginning of the 1990s (scenario *CAP-1988*). Prices of compound feed reduced as well. The average raw material costs for all types of compound feed went down by about 18 ecu per tonne. The protein content of feed decreased from 20.7% in 1990/91 to 20.1% in 1994/95. This is caused in part by a changed price ratio between energy and protein. An opposite movement has also been taking place, i.e. the substitution of a low protein raw material (tapioca) by an medium protein raw material (cereals). As stated earlier the protein content in the CAP-1988 could be slightly underestimated. Projecting the decreasing cereal prices to the future, the results show the same tendency: a further increase of the share of cereals in compound feed and a reduction of the protein content in the compound feed, as well as lower prices of these products.

Comparing *CAP-1994* with *CAP-1988*, the total amount of proteins used increased from 21.3 million tonnes to 22.7 million tonnes. This is mainly due to the increase of production of compound feed.

In conclusion, present agricultural policy (Mac Sharry policy) leads to lower protein content in compound feed as a result of reduced cereal prices and non-cereal raw material prices. This results into a lower excess of nitrogen, assuming unchanged production level. A further decrease of cereal prices will induce a higher uptake of cereals and a lower protein content. World market conditions are important as well and the impact of the assumed soyabean meal price on the outcome is presented in section 5.4.

Use of raw materials at EU level

An important item of CAP in the EU is the self-sufficiency of inputs. Inputs used to produce compound feed mainly consist of home-grown raw materials as well as imported raw material from outside the EU. Soyabean meal, maize gluten feed, tapioca and citrus pulp are mainly imported products, while cereals, beet pulp, brans, rapeseed and sunflower meal and peas are mostly produced inside the EU. *CAP-1994* induces an increase of the amount of cereals used (table 5.6).

Table 5.6 The total use of raw materials for the production of compound feed in EU-12 (in million tonnes) of CAP-1988; and the relative use of CAP-1994 and CAP-2000 (CAP-1988 = 100)

	CAP-1988 (mln. tonnes)	Indices	
		CAP-1994	CAP-2000
Cereals	35.0	127	159
Soyabean meal	17.0	107	87
Maize gluten feed	6.2	107	87
Tapioca	6.0	89	51
Brans	9.2	102	93
Rapeseed and sunflower meal	5.5	105	93
Peas	4.5	78	96
Others	19.6	100	83
Total	102.9	110	110

Source: CCM-model.

CAP-1994 also contributed to a reduction of the amount of tapioca and peas consumed. The amount of soyabean meal, maize gluten feed, rapeseed and sunflower meal and brans remained generally rather stable under the *CAP-1994* scenario. A further reform with decreasing cereal prices (*CAP-2000*) leads to an increasing share of home-grown raw materials. Compound feed production increased by about 10% with *CAP-1994*, compared with *CAP-1988*. Despite this increase, the use of raw materials other than grains drop in absolute terms. To summarise, the model confirms that agricultural policy reforms influence the use of raw materials towards a higher level of self-sufficiency.

5.4 Impact of nutritional management under different agricultural policies

This section explores the impact of nutritional management measures for pigs and poultry. A reduced protein diet (*controlled nutritional management*) as described in chapter 4 is introduced for *CAP-1988*, *CAP-1994* and *CAP-2000* (table 4.1). Such a reduced protein diet was considered in regions of concentrated intensive livestock production, including the Netherlands, Belgium and Luxembourg, northwestern part of France, northern and central part of Germany, the northern part of Italy, Denmark, the northeastern part of Spain and East England. These regions cover well over 70% of the compound feed production to feed pigs, and approximately two thirds of the compound feed production to feed poultry (table 5.7).

The regions where intensive livestock production is concentrated cover a substantial part of the market of compound feed in the EU. Any changes in such regions however also affect market conditions in other regions within the EU. This 'knock-on effect' reflects the interdependence between regions.

Placing extra restrictions on the use of protein by definition lowers protein content of compound feed, and the price of compound feed also increase. Price changes of raw material also are considered in the CCM-model in response to changes in demand and supply of raw materials. The model is based on the assumption that lower demands for protein might induce a reduction of prices of protein rich feedstuffs. This of course could also reduce the final compound feed price.

The total amount of protein shows a downward trend in case of *controlled nutritional management*, but the impact differs depending on the scenarios of agricultural policy. For *CAP-1988* scenario the amount of protein in the total compound feed production in the EU drops by 953,000 tonnes to a total of 20.3 million tonnes. This reduction level is equivalent to 4.5% of the total quantity of protein in compound feed. Under the *CAP-1994* the protein quantity reduces by 911,000 tonnes (-4.0%), while in a future scenario (*CAP-2000*) the amount of protein will decrease with about 484,000 tonnes (-2.3%). The percentage reduction of the amount of protein shows a downward trend over time because high-cereal diets provide balanced diets at lower protein levels. This might be caused by the fact that the absolute protein content is higher in the *CAP-1988* scenario and lower in the *CAP-2000* scenario. The effect of the additional feeding measure on the protein content (to reduce nitrogen pollution further) was higher under the *CAP-1988* regime than under the future *CAP-2000* scenario.

Table 5.7 Regions with controlled nutritional management and their share of compound feed production in the EU (in million tonnes) a)

	CAP-1988		CAP-1994 and CAP-2000	
	pigs	poultry	pigs	poultry
The Netherlands (10) b)	6.7	3.3	6.5	3.4
Belgium and Luxembourg (20)	2.8	1.0	2.7	1.1
Northwestern part of France (31)	3.2	5.0	4.2	6.6
Northern and central part of Germany (41, 42)	2.1	2.8	1.3	3.2
Northern part of Italy (51)	0.9	3.5	1.0	3.4
East England (61)	1.0	2.1	1.1	2.1
Denmark (80)	0.8	0.5	2.1	0.7
Northeastern part of Spain (102)	1.7	1.9	2.6	2.0
Total	19.2	20.1	20.4	22.5
Share of compound feed of these regions in EU-12 (%)	76.5	67.7	73.1	68.8

a) Only compound feed for sows and finishing pigs, exclusive of concentrates (calculation LEI); b) Region numbers correspond with numbers mentioned in figure 1 of appendix A.

Compound feed and nitrogen pollution management

The average price of compound feed increased because of the extra dietary restrictions, which subsequently reduce nitrogen pollution. Compared to *current nutritional management*, total costs increase to 16,875 million ecu (*CAP-1988*), 16,519 million ecu (*CAP-1994*) and 13,875 million ecu (*CAP-2000*). The additional costs of *controlled nutritional management* measures in these scenarios amount to 100, 95 and 43 million ecu.

Because a reduction of protein content might be achieved mainly in feed for pigs and poultry, specific tables for compound feed for both animal types are presented (table 5.8 and table 5.9). The compound feed production which is taken into account is only those for sows and finishing pigs. In total it amounts to about 25 million tonnes (*CAP-1988*) and almost 28 million tonnes (*CAP-1994*). Protein concentrate for pigs is assumed to remain unchanged in the *controlled nutritional management* scenario. Reforming CAP leads to a higher content of cereals, a lower content of soyabean meal in *CAP-2000* (not under *CAP-1994*), a lower protein content and lower costs of compound feed. This was also mentioned in section 5.2.

The impact of nutritional management on price and composition of compound feed is different under each of the agricultural scenarios. The impact of the restricted protein scenario in the period of the late eighties (*CAP-1988*) is greater than under the *CAP-1994* and *CAP-2000*. The future scenario result into the smallest changes. For instance in the *CAP-1988* scenario, cereal content is increasing by 6.0%, while this increase in percentage under *CAP-2000* is only one and a half percent. The lowering content of soyabean meal is largest under *CAP-1988*. Due to agricultural policy reform, the protein content reduces from 17.8% to 15.7%. *Controlled nutritional management* with a lower protein content, is more easily met in a situation which is closer to the desired situation. This is the case in the *CAP-2000* scenario where the protein content is already lower than the situation in the late eighties.

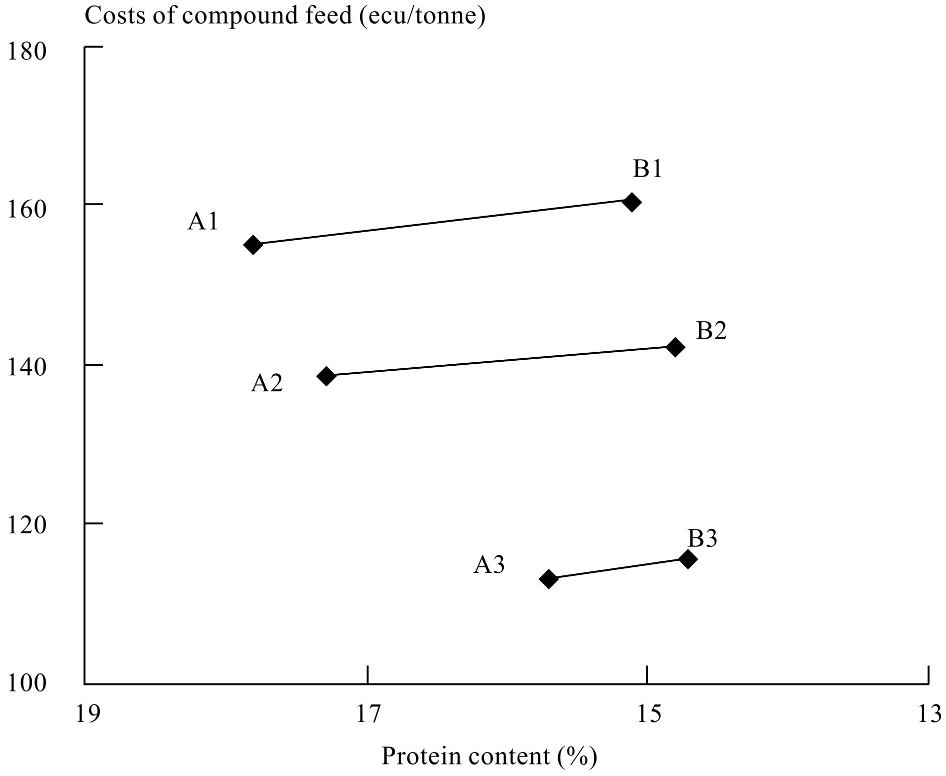

Figure 5.1 Costs and protein content in pig feed

Figure 5.1 shows the relation in the EU between costs of compound feed and the protein content under different case studies of agricultural policy and two types of nutritional management. It includes regions with *controlled nutritional management* and regions with *current nutritional management*. The protein content of pig feed in regions with *controlled nutritional management* (14.4%) is a weight average from growing pigs and sows.
Compound feed is most expensive under the *CAP-1988* scenario and the cheapest under the *CAP-2000* scenario. Costs of compound feed increases under the *controlled nutritional management* while the protein content decreases (from A to B). The length of each of the line represents the reduction of the protein content. The slope of the line gives an indication of the extra costs of compound feed to meet the protein restrictions. The final protein content of pig feed in the EU is not equal in both three situations (B1, B2, B3). In those regions where *controlled nutritional management* is dictated the final protein content is in all cases equal to the upper limit. In the remaining regions *current nutritional management* is allowed. Changes in the composition of compound feed are due to the differences in final protein content.

The total costs of compound feed for sows and finishing pigs increase by 123 million ecu. This is equivalent to some 3.2% of the total costs of pig feed under *CAP-1988*. These extra costs are lower under *CAP-1994* and further reduced under the future agricultural policy. The relative increase is smaller because the total costs also show a decreasing trend (*CAP-1994*: 2.6% , *CAP-2000*: 1.9%). Changes in composition and price are marginal under the *CAP-2000* scenario compared to the *CAP-1988* scenario.

Table 5.8 Price and composition of the compound feed (excluding concentrate) for pigs in EU-12 under 6 different scenarios

Nutritional management	CAP-1988		CAP-1994		CAP-2000	
	current	controlled a)	current	controlled a)	current	controlled a)
Compound feed production (million tonnes) b)	25.1	0	27.9	0	27.9	0
Composition (% of total)						
- cereals	32.0	6.2	40.2	4.3	52.0	1.5
- soyabean meal	10.0	-3.6	10.0	-2.8	7.7	-2.8
Protein content						
- (1,000 tonnes)	4,470	-683	4,820	-685	4,370	-280
- in % of total	17.8	-2.7	17.3	-2.5	15.7	-1.0
Total costs of compound feed on raw material level (in million ecu)	3,897	123	3,870	100	3,159	60
Average price (ecu/tonne)	155.4	5.0	138.6	3.6	113.1	2.2
Extra costs of the *controlled nutritional management* compared to *current nutritional management*						
- in ecu/tonne protein		180.1		146.0		214.3
- in ecu/kg N		1.1		0.9		1.3

a) Deviation from *current nutritional management;* b) Only compound feed for sows and finishing pigs, exclusive concentrate.
Source: CCM-model.

The extra costs of nutritional management measures need to be compared with their benefits for the environment. Benefits for the environment include the amount of protein which have not been fed and consequently not have been excreted by the animals. The extra feeding costs per tonne of 'not fed' protein are shown in table 5.8 and table 5.9. Under *CAP-1988* the extra costs of the *controlled nutritional management* per tonne of protein are 180.1 ecu/tonne (123 million ecu, related to 683,000 tonnes of protein) . Under the *CAP-1994* the extra costs per tonne of protein are 146 ecu/tonne, which are lower compared to the costs of *CAP-1988*. This means that under the *CAP-1994* it is cheaper to introduce a protein restricted feeding measure. This can be explained by the increasing price gap between grain and protein concentrates under *CAP-1994*. However, when introducing *controlled nutritional management* in a future agricultural policy scenario, the extra costs per tonne of protein rise to 214.3 ecu/tonne. This is a result of on the one hand even lower extra costs of additional feeding measure but on the other hand a marginal protein reduction (280,000 tonnes). The gain of this additional feeding measure is less in the *CAP-2000* scenario, as protein levels will be potentially lower in any case. The absolute value of the lower protein diet will still be cheaper than the *CAP-1988* and *CAP-1994* scenarios. A large part of the target will be achieved by *CAP-*

2000. Although CAP itself will achieve a lower protein content in its compound feed, additional feeding measures are required to meet the targeted low protein diet.

The situation in the poultry sector is similar to that of the pig sector. The total consumption of compound feed is estimated on 29.7 million tonnes in 1990/91 and 32.7 million tonnes in 1994/95. Under the *CAP-2000* scenario the consumption is assumed to remain unchanged. The feed formulation required a higher cereal and soyabean meal content and a higher protein level. See table 5.9. The influence of agricultural policy on poultry compound feed is comparable to those in pig feed, although changes in composition are relatively small.

Introducing *controlled nutritional management* as described in chapter 4 leads to a higher uptake of cereals, a lower uptake of soyabean meal and a lower protein content. The extra costs to reduce the protein content are lower in poultry feed than in pig feed because of the fact that the reduction in protein content in the former is less.

In figure 5.2 the relationship between the costs of compound feed and the protein content are shown. The costs of compound feed are the highest in case of the *CAP-1988* scenario and the lowest in the *CAP-2000* scenario. The slope of each of the three lines is very small, meaning a minimal price increase of compound feed caused by the protein restriction. Otherwise the same principles apply as described for the pig sector.

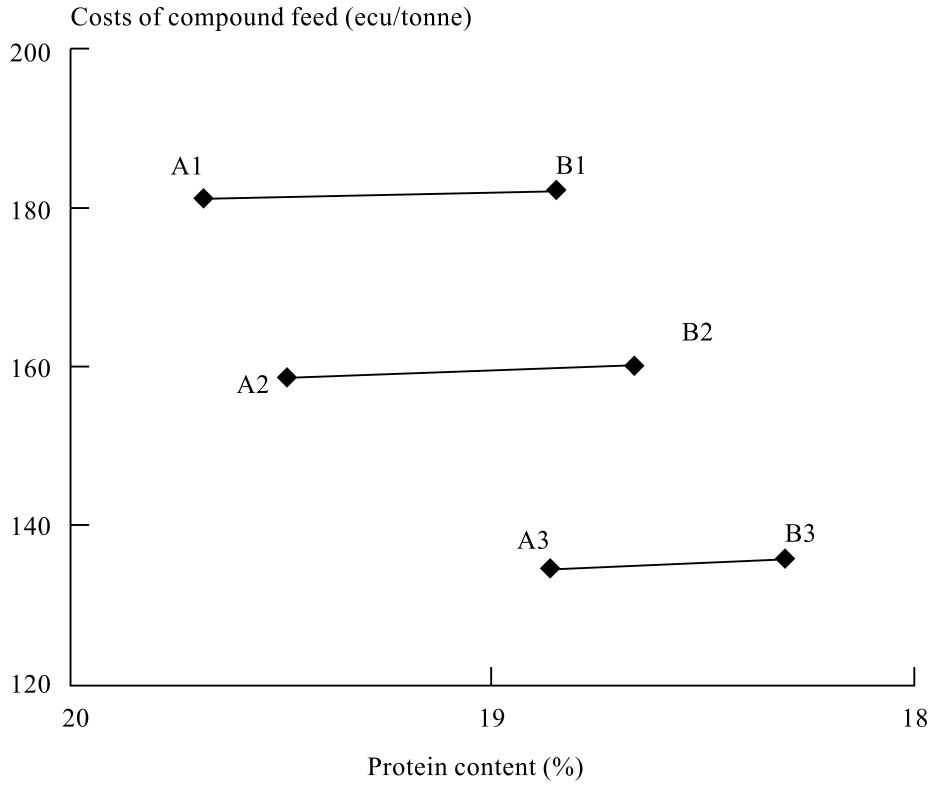

Figure 5.2 Costs and protein content in poultry feed

Table 5.9 Price and composition of the compound feed for poultry in EU-12 under 6 different scenarios

Nutritional management	CAP-1988		CAP-1994		CAP-2000	
	current	control-led a)	current	control-led a)	current	control-led a)
Compound feed production (million tonnes)	29.7	0	32.7	0	32.7	0
Composition (% of total)						
- cereals	56.3	1.3	57.6	0.9	60.2	0.9
- soyabean meal	15.4	-1.6	15.7	-0.9	14.3	-1
Protein content						
- in 1,000 tonnes	5,820	-240	6,361	-233	6,143	-164
- in % of total	19.6	-0.8	19.4	-0.7	18.8	-0.5
Total costs of compound feed on raw material level (in million ecu)	5,383	18	5,200	6	4,393	3
Average price (ecu/tonne)	181	1	159	0	134	0
Extra costs of *controlled nutritional management* compared to *current nutritional management*						
- in ecu/tonne protein		75.0		25.6		18.3
- in ecu/kg N		0.47		0.2		0.11

a) Deviation from *current nutritional manegement*.
Source: CCM-model.

Table 5.10 The relative use of raw materials to the production of compound feed in the EU-12, controlled nutritional management compared to current nutritional management (current nutritional management = 100)

Raw material	CAP-1988	CAP-1994	CAP-2000
Cereals	104	105	100
Soyabean meal	91	95	96
Maize gluten feed	96	88	95
Tapioca	101	111	133
Brans	92	94	97
Rapeseed and sunflowermeal	110	91	101
Peas	100	110	95
Others	102	97	103
Total	100	100	100

Use of raw materials at EU level

Controlled nutritional management contributes to a reduction of the use of soyabean meal. As a consequence, the use of synthetic amino acids is higher. The use of tapioca and cereals will be higher still where nitrogen excretion is targeted for further reduction. As explained in section 5.2 the self-sufficiency of inputs is an important item of the EU. *CAP-1994* leads to a higher self-sufficiency status.

Controlled nutritional management improves the self-sufficiency rate of protein. This is due a reduction of the import of soyabean meal. The relationship between the raw materials imported changes, with an increase of tapioca and a reduction of soyabean meal and maize gluten feed.

Impact of CAP reform and feeding measures to costs of compound feed

Following *CAP-1994* and *CAP-2000* (and *current nutritional management*), costs of compound feed to grow pigs reduce from 139 ecu/tonne to a level of 113 ecu/tonne. The nitrogen content of feed reduce by some 9% because of the change in the composition of feed. The reduction of nitrogen content of feed could be reduced by some 15% by comparing costs of compound feed (*current nutritional management*, *CAP-1994*) with the case of *controlled nutritional management* (*CAP-2000*) (table 5.11).

Table 5.11 Indices of costs of compound feed (ecu/tonne) and nitrogen content of feed (kg N per tonne of compound feed) for pigs and poultry by agricultural policy and type of nutritional management

Nutritional management	Pigs		Poultry	
	current	controlled	current	controlled
Indices of costs (ecu/tonne)				
CAP-1988	100	103	100	101
CAP-1994	89	92	88	88
CAP-2000	73	74	74	74
Indices of N-content feed (kg N/tonne feed)				
CAP-1988	100	85	100	96
CAP-1994	97	83	99	95
CAP-2000	88	83	96	93

A reduction of the nitrogen content in pig feed of some 15% (*CAP-1988*) increases costs of compound feed by some 3%. In case of *CAP-2000*, the nitrogen content of compound feed is some 12% lower compared to *CAP-1988*, and costs of compound feed level are 27% below that of *CAP-1988*. In table 5.11 the final nitrogen content is about 17% lower in the *CAP-2000* (*controlled nutritional management*) scenario compared to CAP-1988. As was stated earlier the variation is due to a reduction of nitrogen content in those regions where *controlled nutritional management* was not required. A further reduction to 15% less nitrogen in *CAP-2000* will cost less than 1% of the total costs of *CAP-1988*. The current CCM-model does not calculate marginal costs of nutritional management measures. The linear-programming tool only provides insight on the average costs of measures taken.

Impact of soyabean meal price (SBM)

Prices of raw material affect the composition of compound feed, and pricing of soyabeans are important in this respect. Different price scenarios on the world market of soyabeans are explored and their impact on the composition of compound feed are assessed with the CCM-model. A distinction is made between price level which is substantially above (+36%, HIGH) and below (-33%, LOW) prices used in the model for *CAP-2000*. Results are summarized in table 5.12.

According to the prices considered, the use of SBM could range between 10 and 22 million tonnes. The use of other raw materials used in the diets change as well. The effect of the SBM price on the protein content in total EU compound feed will be dependent on the relative prices of other raw materials. However, a change in SBM price will also affect the price of other protein rich raw materials. A higher price of SBM is considered to increase the demand for rapeseed meal which will also raise the price of rapeseed meal. Therefore, the price of soyabean meal may influence directly the effectiveness of using only CAP reform to manage excess nitrogen pollution. It may be appropriate to take environmental protection measures in order to minimize the negative effects of low soya prices.

Table 5.12 Impact of soyabean meal price on the use of raw materials and protein content in the total compound feed production in the EU

	CCM-model (current)	HIGH	LOW
SBM price (ecu/tonnes)	159	217	106
Use of SBM in EU-12 (1,000 tonnes)	14,801	9,812	22,192
Use of competitive raw materials			
(i.e. rapeseed and sunflower meal)	5,219	6,566	2,353
Use of cereals	55,574	60,614	48,182
Protein			
- total use (1,000 tonnes)	20,695	20,194	23,744
- in %	18.3	17.9	21.0

Source: CCM-model.

5.5 Concluding remarks

1. Feed formulas are generally calculated by computer to meet a set of nutritional constraints at the least possible cost per tonne. Least cost formulas rarely correspond to the most environmental friendly feeds. The main factor influencing the cost of a reduction of the protein content in feed is the difference between the grain and protein-based-feedstuffs prices (soyabean meal). This is due to the relatively high gearing of the cereal grain to protein source price ratio. Through a reduction of the cereal intervention price,

the CAP reform has consequently a direct and positive impact on the economical feasibility of environmental friendly feeds.

2. The reform of CAP implemented in 1992 contributed to a reduction in costs of compound feed raw materials. On average the price of compound feed at raw material level was reduced by some 10% (*CAP-1994*). Compared to the situation by the late 1980s, this might be reduced by some 25% (*CAP-2000*). Following this trend, the reform of CAP also contributes to an increase on the share of cereals in compound feed and a reduction on the protein content of compound feed. The protein content of compound feed in the EU on average lowers from 20.7% (*CAP-1988*), 20.1% (*CAP-1994*) and 18.3% (*CAP-2000*). This trend is induced by changing price relationships between protein and energy crops. However, the reform in 1992 increased specifically the use of wheat which due to an unbalanced amino acid profile, further increased the protein level in least cost formulations in the absence of supplementary amino acids.
3. Nitrogen content of compound feed might be reduced by a combination of agricultural policy reform measures and nutritional management measures.
   An approximately 15% reduction of the nitrogen content of feed for pigs might have been achieved by the late 1980s. This would have required *controlled nutritional management* and increased costs of compound feed by some 3%.
   The reform in 1992 reduced the cost of nutritional management and provided some incentive to reduce nitrogen content of feed.
   A substantial reduction of nitrogen content in feed would be achievable with a new reform of CAP, contributing to a large reduction of protein content in feed.
4. Any changes in agricultural policy with low protein diets which are caused by the lower cereal prices, will further facilitate nutritional management: the additional costs to produce a low protein diet show a decreasing trend. However, the additional gain to be made, in terms of reducing nitrogen input, gets less. This implies that the marginal costs per kg of nitrogen reduced of the low protein diet show an increasing trend in a future scenario compared to the present situation. An assessment has been made on the costs to reduce pig compound feed by 1 kg of nitrogen per tonne. In the EU these costs amount to 1.1 ecu (*CAP-1988*), 0.9 ecu (*CAP-1994*) and 1.3 ecu (*CAP-2000*).
5. The CAP influences the use of raw materials towards self-sufficiency in protein. This is caused by a higher uptake of home grown cereals. The impact of a low protein diet for pigs and poultry on the self-sufficiency of the EU is different. The importation of protein compound of soyabean meal decreases; in comparison the import of tapioca will increase. A mix of both products can however easily be replaced by wheat or barley.
6. There are many factors, including world market conditions which may play a very significant role in allowing nutritional management measures to go beyond current practice. Soyabean meal prices would largely affect the protein content in compound feed. A reduction of soyabean meal prices may lead to important dietary protein increases. This may also reduce the potential of nitrogen pollution control. In order to minimise the negative effects on nitrogen pollution of low prices of soya and protein-based raw materials, environmental protection measures may be appropriate to ensure low dietary protein levels in feed formulations.

6. Nutritional management and costs to remove excess nitrogen from manure at farm level

6.1 Introduction

This chapter provides insight into the costs of different measures to reduce excess nitrogen from manure for the individual producer. The costs of introduction of an improved nutritional management will be compared to the costs of manure removal. It will also become clear whether national legislations presently achieve the objectives of the Nitrates Directive.

The analysis focuses on granivore farms because of the potential benefits of nutritional management measures to reduce excess amounts of livestock manure. Particularly with this farm type, it may be a useful option to reduce nitrogen pollution at its source of production. In the Netherlands, more than 90% of total input of nitrogen at granivore farms consists of feed concentrates (Poppe et al., 1995). According to prevailing standards, a large share of animal manure produced at such farms is typically applied elsewhere. The assessments are limited to the role of nutritional management at farm level; emphasis is given to the costs to remove excess nitrogen from manure compared to the option of *controlled nutritional management*. In comparison, a regional evaluation to remove excess of manure is provided in the next chapter.

First, the impact of manure policies in the EU will be assessed by the Farm European Mineral Model (FEM-model). A brief description of the model, the assumptions made and the data used is given in appendix B. This model is especially suitable to quantify the consequences of agricultural and environmental policies on income and mineral balances at farm level in the EU. The analysis addresses mainly changes of nitrogen flows in response to changes of policy.

The analyses made regarding removal of excess nitrogen and costs of nutritional management are described below. The impact of *controlled nutritional management* under *CAP-2000* on the gross margin and on nitrogen balances at farm level is investigated for a number of regions in the EU in section 6.2. The relationship between costs to remove excess nitrogen from manure, and costs of nutritional management is investigated at different stages of agricultural policy in section 6.3. Finally, in section 6.4 some of the findings on the assessment are summarized.

Scenarios assessed

The scenarios on agricultural policy which are applied in this chapter are described in Appendix E of the report. Scenarios applied distinguish between two types of nutritional management (*current nutritional management* and *controlled nutritional management* measures). Translation of policies into model terms is briefly described below.

CAP-1988, considering national legislation

CAP-1988 reflects 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.

Present existing agri-environmental policy in the Member States (Rude and Frederiksen, 1994) is considered as well, because it already affects farmers, and contributes to the meeting of environmental standards. Policy measures implemented before 1995/96 are considered in the analysis in a simplified way. For Belgium and the Netherlands it is assumed that the application of animal manure should not exceed 125 kg P_2O_5 ha^{-1} for arable crops and 175 kg P_2O_5 ha^{-1} for grass and fodder maize. For Denmark maximum application standards of animal manure considered are 200 kg N ha^{-1}. In France and Spain manure application standards of 350 kg N ha^{-1} for grassland and 200 kg N ha^{-1} for arable crops and fodder maize are assumed. Granivore farms are already affected by national environmental legislation. Costs to remove excess nitrogen from manure are considerable, because of the large amounts of manure to be removed at such holdings.

CAP-1994, considering 1992 CAP Reform

The price reduction of outputs and feed concentrates under the 1992 CAP Reform are exogenous in the FEM-model. The most important output price reductions assumed are a price decrease for pig meat of 6%, for poultry meat of 11% and for eggs of 10%.

CAP-2000, considering an application standard

CAP-2000 considers an application standard of 170 kg of nitrogen per hectare from organic manure. The remaining amount of manure has to be removed in the approach used. This standard is one of the main elements of the Nitrates Directive, which will be fully implemented by the year 2003. This scenario considers a 10 per cent reduction of intervention prices, whereas *CAP-1988* and *CAP-1994* use market prices.

Removal costs

Removal costs are assumed to be 1 ecu per kg of nitrogen in the scenarios CAP-1988 and CAP-1994. Under stricter environmental policy more manure may be removed in regions with high concentration of manure production and the removal costs per kg N will increase. Costs of 2 ecu per kg of nitrogen removed are assumed under *CAP-2000*. This level is derived from the expected level in the Netherlands under strict policy. The calculations in section 6.2 are interpreted as examples of how nitrogen balances might change under strict policy.

Costs of feed concentrates

The costs of feed concentrates are based on results of the CCM-model and are presented in appendix table A.3.

6.2 Impact of nutritional management on intensive livestock production in the European Union

The results are based on weighted averages of a sample of individual optimised farms. The farm structure of the granivore farms selected is presented by region in table 6.1.

The relatively small size of utilized agricultural area per farm, and the high livestock population are major determinants of the high rates of manure disposed at granivore farms. Utilized agricultural area is below 6 hectare in Belgium, Cataluna and the Netherlands. It is relatively high in Denmark and Bretagne (table 6.1). Livestock density of granivore farms exceeds 35 Livestock Units per hectare (LU/ha) in Belgium, Cataluna and the Netherlands. Manure production exceeds 2,000 kg of nitrogen per hectare in these countries.

Table 6.1. Farm structure of granivore farm in the regions

	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
Cataluna	5	37.3	76	24
Bretagne	23	10.5	76	22
Netherlands	4	58.1	61	37

Source: FEM model results LEI.

Results of *CAP-1988* and *CAP-1994* with *current nutritional management*, together with *CAP-2000* with *current nutritional management* and *controlled nutritional management* are presented for granivore farms in Belgium, Denmark, Cataluna (Spain), Bretagne (France) and the Netherlands in table 6.2. The case of *controlled nutritional management* under *CAP-1994* is not presented in these tables. The assumed level of removal costs of 1 ecu per kg of nitrogen under *CAP-1994* is too low to introduce *controlled nutritional management* (see also figure 6.2). The gross margin and manure production and removal are presented under the scenarios assessed. Livestock composition and density do not change.

Granivore farms are already affected by national environmental legislation. Considerable amounts of organic manure have to be removed from the farm at present to meet national environmental standards. In Belgium and the Netherlands national policy focuses mainly on phosphate. More than 1,500 kg of nitrogen has to be removed per hectare at granivore farms in Belgium, Cataluna and the Netherlands (table 6.2).

Table 6.2 Gross margin (x 1,000 ecu) and manure production and removal (kg N/ha) on granivore farms

Country/Region	Scenario	CAP-1988	CAP-1994	CAP-2000	
	nutritional management	current	current	current	controlled
Belgium	gross margin	163.3	157.7	163.8	165.0
	manure production	2,267	2,217	1,964	1,708
	manure removed	1,560	1,520	1,401	1,196
Denmark	gross margin	140.1	141.6	153.1	153.3
	manure production	354	347	298	259
	manure removed	97	94	69	37
Cataluna	gross margin	72.3	64.6	70.2	70.3
	manure production	2,812	2,837	2,542	2,227
	manure removed	2,016	2,038	1,863	1,612
Bretagne	gross margin	136.9	137.9	146.6	147.1
	manure production	570	562	485	429
	manure removed	243	236	218	173
Netherlands	gross margin	144.5	134.3	134.1	136.5
	manure production	3,582	3,646	3,341	2,743
	manure removed	2,607	2,658	2,507	2,029

Source: FEM model results LEI.

Under CAP-1994 with *current nutritional management*, the amount of nitrogen produced is reduced and consequently the amount which needs to be removed is less, because of the lower level of nitrogen excretion level per animal. The change of the gross margin is not only the result of the reduced amount of nitrogen from manure which has to be removed but also of the price change of feed concentrates and outputs as a result of the *CAP-1994*. In Belgium and the Netherlands the gross margin of granivore farms decreases under the CAP Reform in spite of the lower feed concentrate price. In Denmark and Bretagne the gross margin increases, the price advantage of feed concentrates compensates for the decrease in output prices. The components which determine the change in gross margin are presented for Bretagne and the Netherlands in table 6.3.

The reduction in nitrogen which needs to be removed under *CAP-2000* with *current nutritional management*, compared to *CAP-1994* is determined by the lower mineral contents of animal manure and the restriction on the application of animal manure. Less organic manure has to be removed, since less organic manure is produced (while stocking density remains constant). However, more organic manure will still have to be removed, since the application standard is more strict than existing national environmental policy. The application standard is not met on average at granivore farms under national legislation. The change of the gross margin under *CAP-2000* compared to CAP-1994 (both with *current nutritional management*) is mainly the result of the higher disposal cost level assumed under strict policy and the reduction in feed concentrate costs (table 6.3). The gross margin increases in all regions assessed, except in the Netherlands.

Table 6.3 Components which determine the percentage change of the gross margin in Bretagne

Scenario	CAP-1994 compared to CAP-1988	CAP-2000 compared to CAP-1994	CAP-2000
Nutritional management	current	current	controlled compared to current
Bretagne			
Percentage change in gross margin (%)	0.7	6.3	0.3
As a result of			
- changes in the amount of manure removed	0.1	0.4	1.3
- higher costs to remove excess nitrogen from manure		-3.6	
- change in feed concentrate price	12.0	9.5	-1.0
- change in output prices	-11.4		
Netherlands			
Percentage change in gross margin (%)	-7.1	-0.1	1.8
As a result of:			
- changes in the amount of manure removed	-0.2	0.5	2.8
- higher costs to remove excess Nitrogen from manure		-7.5	
- change in feed concentrate price	7.5	6.9	-1.0
- change in output prices	-14.4		

Source: FEM model results LEI.

Controlled nutritional management decreases the manure production and consequently the amount of nitrogen to be removed (table 6.2). The total removal costs will be lower. However, the price of feed concentrates will increase for most animal species under the *controlled nutritional management* (chapter 5). There are very marginal income levels in this sector, which are around the cost increases of feed concentrate. The decrease in removal costs exceeds the increase in feed costs in all regions assessed and the gross margin is higher when an environmentally-based nutritional management is introduced and removal costs are 2 ecu per kg N. It becomes clear that the level of removal costs are a crucial element in the analysis.

6.3 Relationship between costs to remove excess nitrogen from manure and use of nutritional management to reduce nitrogen in feed

Controlled nutritional management will be only introduced in case the reduction in the costs to remove excess nitrogen from manure exceeds the increase in feed costs for using nutritional management measures. Therefore some sensitivity analyses are done with different cost levels assumed to remove excess nitrogen from manure. This indicates at which cost level nutritional management measures become beneficial compared to alternative measures to remove excess nitrogen from manure.

The introduction of a lower protein diet is investigated at the different stages of agricultural policy distinguished; *CAP-1988*, *CAP-1994* and *CAP-2000*. It is also investigated whether there are differences between regions in the minimum level of costs to remove excess nitrogen from manure in comparison with reducing nitrogen input by nutritional management.

Figure 6.1, 6.2 and 6.3 show the gross margin under successively *CAP-1988, CAP-1994* and *CAP-2000* for different disposal cost levels with *current nutritional management* and *controlled nutritional management* in the Netherlands. A better nutritional management will be only introduced when the cost level to remove excess nitrogen from manure exceeds the disposal cost level in the point of intersection of both lines. Maximization of the gross margin is considered to be the primary objective of farmers.

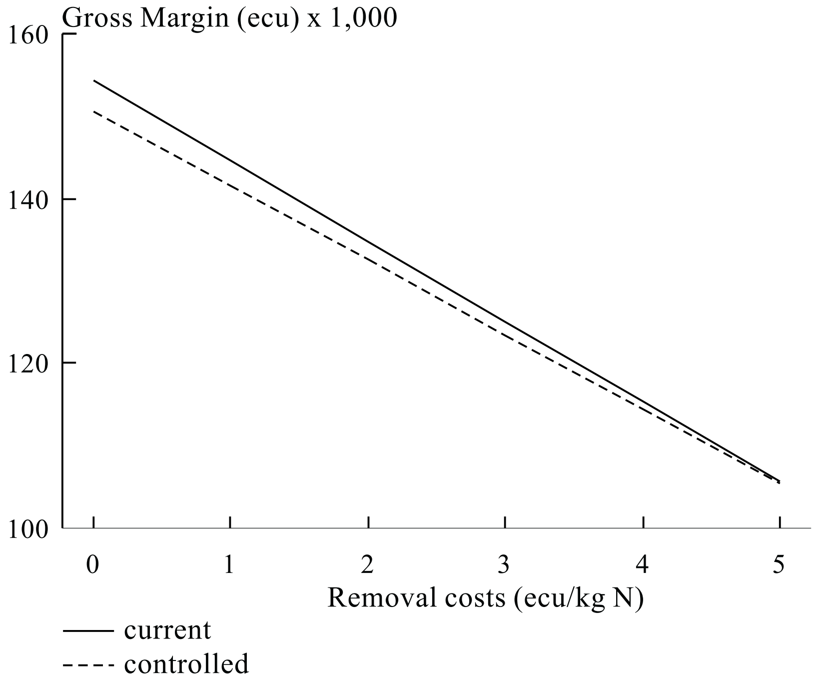

Figure 6.1 Gross margin under CAP-1988 with current nutritional management and controlled nutritional management for different cost levels to remove excess nitrogen from manure in the Netherlands
Source: FEM model results LEI.

Controlled nutritional management remains rather costly under *CAP-1988*. In such conditions the removal of excess of nitrogen from manure remains beneficial compared to the method of nutritional management. *Controlled nutritional management* only become viable at removal costs of around 5 ecu per kg of nitrogen. These by far exceed present costs to remove excess of nitrogen from manure (figure 6.1). Under *CAP-1994* nutritional management will be introduced at a lower level of disposal costs; above 2.5 ecu per kg N (figure 6.2).

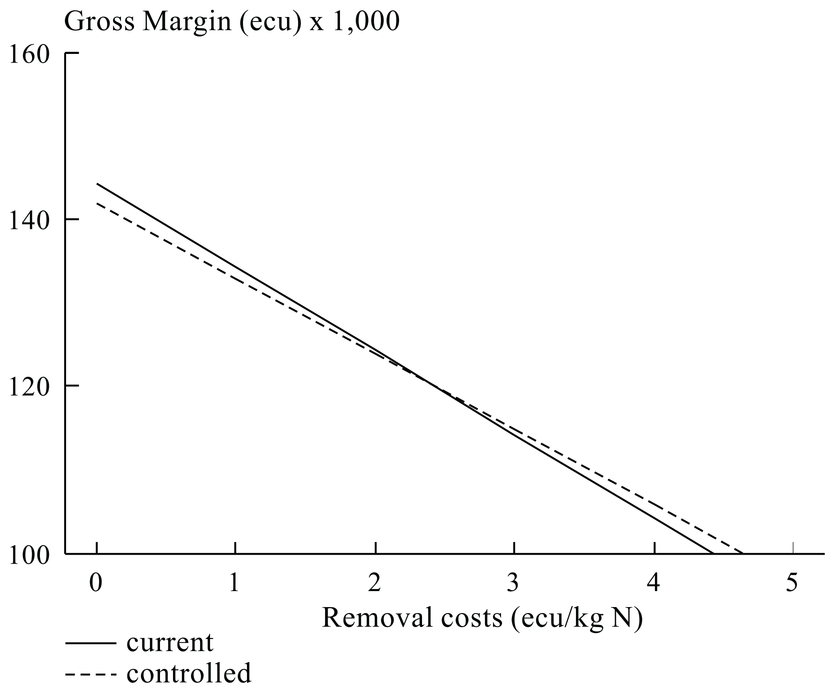

Figure 6.2 Gross margin under CAP-1994 with current nutritional management and controlled nutritional management for different cost levels to remove excess nitrogen from manure in the Netherlands
Source: FEM model results LEI.

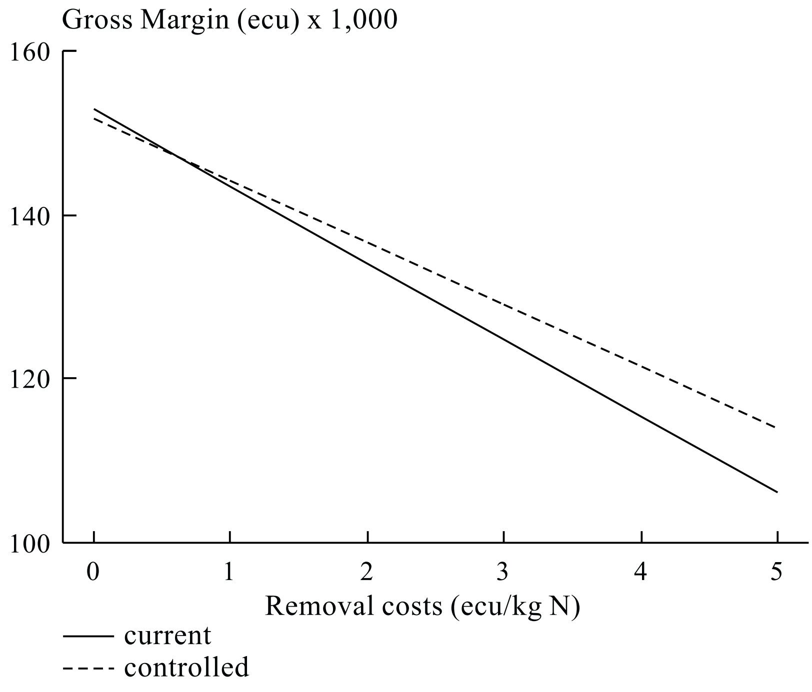

Figure 6.3 Gross margin under CAP-2000 with current nutritional management and controlled nutritional management for different cost levels to remove excess nitrogen from manure in the Netherlands
Source: FEM model results LEI.

CAP-1994 made the realization of lower protein levels in feed concentrates cheaper (see chapter 5). The switch to low protein feed is therefore cheaper compared to *CAP-1988* and will be realised consequently at a lower level of disposal costs. Under *CAP-2000* the minimum level of disposal costs for introduction is further reduced to a level of 0.64 ecu per kg N (figure 6.3).

Figure 6.4 shows the minimum level of costs to remove excess nitrogen from manure in Bretagne under *CAP-2000* for introduction of nutritional management. In the Netherlands (figure 6.3) it will be introduced at a lower level of removal costs than in Bretagne. In Belgium the minimum level of removal costs for introduction is comparable to the level in the Netherlands (below 1 ecu per kg N). In Denmark and Cataluna the minimum level is comparable to the level in Bretagne (between 1 and 2 ecu per kg N).
The costs to remove excess of manure in the Netherlands on average presently exceeds 1 ecu per kg N which means that *controlled nutritional management* will be introduced in *CAP-2000*. In the future, policy will be even more strict and the level of disposal costs will consequently increase further. The beneficial effects of *controlled nutritional management* therefore increase over time due to the rising costs to remove excess nitrogen from manure.

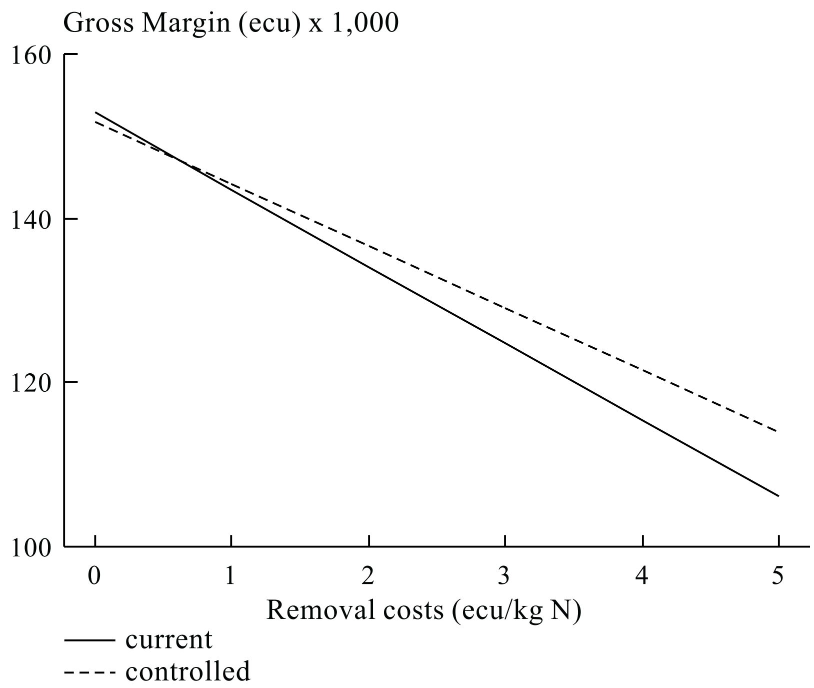

Figure 6.4 Gross margin under CAP-2000 with current nutritional management and controlled nutritional management for different cost levels to remove excess nitrogen from manure in Bretagne
Source: FEM model results LEI.

6.4 Concluding remarks

1. Granivore farms presently are influenced by existing national environmental legislation. Considerable amounts of manure are being removed to meet national environmental standards. These farmers need to further adjust farming practice in order to meeting the objectives and requirements of the Nitrates Directive. The costs to remove excess amounts of manure produced are likely to further increase in the future due to stricter regulation on the management of livestock manure. This provides incentives for preventive measures to control nitrogen pollution (e.g. by nutritional management).
2. The reform of agricultural policy makes nutritional management measure with reduced protein diets beneficial to remove excess of manure at lower costs. Such measure imply a reduction of the excess amount of organic manure produced, and consequently less manure needs to be removed.
3. Introduction of controlled nutritional management depends on the level of removal costs in the region. It is beneficial in economic terms where the reduction of costs to remove excess amounts of manure exceeds the increase in feed costs. The analysis performed in this chapter indicates regional differences in the minimum level of removal costs to introduce controlled nutritional management. An increase on disposal costs will provide incentives for the introduction of a better nutritional management. Strict environmental policy will increase the disposal costs further. At regional level, the increasing pressure on the market to remove excess manure largely depends on the increase in the amount of manure removed at other farming types. This applies, among others, to dairy farms (Hellegers, 1996).
4. Costs to remove excess amounts of nitrogen from manure may differ largely among farms. The beneficial role of feeding measures are likely to be highest at holdings which dispose excess of manure over long distances at high costs.
5. The adjustment processes considered in this report are rather limited and certainly do not intend to reflect dynamic processes of individual farmers. Therefore the results of the partial analysis must be interpreted with the necessary care and are not aimed at assessing macro-economic effects of policy measures. This requires a sectoral approach considering all farm types and a wide variety of possible adjustment processes. Nevertheless, the results obtained can be used to indicate effects in terms of changes of nitrogen flows in response to changes of policy.

7. Options and costs to dispose excess manure from livestock at regional level

7.1 Introduction

Objective

The objective of this chapter is to explore available options to dispose excess of manure from livestock and to a lesser extent also to quantify costs of the various options explored. This chapter looks at regional effects and includes all livestock (also including grazing livestock). The previous chapter gave the effects of the removal of excess nitrogen from manure at farm level and was limited to granivore farms. The inclusion of all livestock is essential in this chapter, because manure from cattle also affect options to dispose of excess manure. In terms of the disposal room which is available at regional level, manure from cattle may compete with manure from pigs and poultry. Options chosen by farmers therefore depend on the pressure on the manure market.

The potential beneficial role of nutritional management is compared with alternative options to dispose manure (e.g. distribution or processing of animal manure; reduction of livestock production) in reducing nitrogen pollution from livestock.

Calculations are made both for Bretagne and the Netherlands. Bretagne is considered to be representative for European regions having high nitrogen surpluses; in comparison nitrogen pollution problems are considered to be most acute in the Netherlands. In case of Bretagne (section 7.2) only the options to dispose excess of manure are described. An assessment of the costs of alternative measures has been not possible for the region of Bretagne because of data limitations. Results for the Netherlands are described in section 7.3 (options to dispose excess of manure) and section 7.4 (costs to dispose excess of manure). These calculations are based on the *application standard*. Also, an assessment is made on the options and costs to dispose excess of manure in the Netherlands with a scenario of *mineral balances* (section 7.5). Some concluding remarks on the options explored are presented in section 7.6.

Approach used

The assessment provided in this chapter is based on a modelling tool which explores alternative manure strategies, assessed at regional level. This model was developed to quantify the emissions of ammonia as well as the excess amounts of manure from livestock production in the Netherlands (Luesink, 1993; Luesink and Van der Veen, 1989). The model calculates the amount of manure produced at farm level, as well as the amount of manure which could be applied according to prevailing standards (see appendix C). Any remaining amounts are accounted for as excess amounts of animal manure, which need to be removed from the holding. A linear programming approach is used to quantify excess amounts of livestock manure and to assess the costs of manure disposal. A distinction is made between application, transport, processing and export of animal manure.

Nutritional management will reduce the excess amounts of manure, and will effect the decision as to which option may be used preferentially. The impact of nutritional management will be compared with alternative measures to remove excess of manure.

Scenarios used

In this chapter scenarios for agricultural policy include *CAP-1994* and *CAP-2000*. Results on *CAP-2000* are presented for three nutritional management measures distinguished, including (a) *current nutritional management*; (b) *controlled nutritional management*; and (c) *potential nutritional management*.

CAP-1994 is based on the consideration of *current nutritional management* (Poppe et al., 1995). The environmental policy to be analysed in this chapter includes limits on the application of livestock manure deriving from the Nitrates Directive (*Application standard*). This scenario is explored for Bretagne and the Netherlands. In addition, the assessment for *CAP-2000* also explores the impact of two alternatives on legislation in the Netherlands (*Application standard*, and a policy targeted on nutrient surpluses, including nitrogen and phosphate, *Mineral balance*). Calculations for the Netherlands are made, both in terms of the excess amounts of manure produced and the costs involved.

7.2 Excess of manure in Bretagne

Total nitrogen production in 1993 (*CAP-1994*, with *current nutritional management*) amounts to 316 million kg in Bretagne (table 7.1). This is equivalent to an average of 220 kg N/ha. About 60% originates from cattle. The relative share of pigs and poultry in total manure production respectively are 30% and 10%. Excess amounts of livestock manure are 59 million kg of nitrogen, with 60% to be accounted for by pig production; the remaining 40% is mainly accounted for by poultry production (table 7.2).

Table 7.1 Supply of nitrogen from livestock manure by animal type in Bretagne (in million kg of nitrogen)

Livestock	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000		
Nutritional management	current	current	controlled	potential
Cattle	180	164	164	164
Pigs	102	94	86	70
Poultry	33	32	26	22
Total	316	291	277	257

Source: LEI.

CAP-1994 is considered to reflect conditions for the year 1993. *CAP-2000* is based on the consideration of the amount of nitrogen produced in the year 2005. Manure production from cattle may decrease by 9% in response to the rising productivity of dairy cattle herd. Livestock population of pigs and poultry is considered to remain constant and the reduction in supply of nitrogen from manure is due to nutritional management (phase feeding and better technical achievements). The total reduction of nitrogen production from livestock between *CAP-1994* and *CAP-2000* amounts to 25 million kg. This is equivalent to a reduction of 8%. About one third of this reduction is due to nutritional management. Calculations are based on the assumption that no feeding measures are taken by cattle to reduce dietary protein levels. Such measures are only considered here for the production of pigs and poultry.

Compared to *current nutritional management* under *CAP-2000*, the nitrogen content of manure from pigs and poultry shows a further reduction of 14 million kg of nitrogen by taking *controlled nutritional management* measures (table 7.1). This is equivalent to a reduction of 5% of the total amount of nitrogen produced in Bretagne, and 11% of the total amount of nitrogen produced by pigs and poultry.

Potential nutritional management would reduce nitrogen production from pigs and poultry manure by some 34 million kg compared to *current nutritional management*. A reduction of some 12% of the total nitrogen production and 27% of the nitrogen production of pigs and poultry could be achieved with such nutritional measures.

Table 7.2 shows the assessments made at farm level regarding the excess amounts of nitrogen from livestock manure. Figures derive from manure policies which are limited to an application standard of 170 kg N/ha. The *application standard* includes limits on the application of livestock manure which derive from the Nitrates Directive.

Table 7.2 Excess amount of nitrogen from livestock manure at farm level in Bretagne, and maximum disposal room for application of manure at holdings with disposal room in Bretagne (in million kg of nitrogen)

Animal type/disposal room	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with application standard		
Nutritional management	current	current	controlled	potential
Cattle	1	5	5	4
Pigs	35	40	34	24
Poultry	23	23	19	15
Total nitrogen	59	68	58	44
Manure (million tonnes)	5.0	6.6	6.2	5.4
Disposal room	160	62	63	66

Source: LEI.

Under *CAP-1994*, the excess amount of nitrogen is 59 million kg (exclusive of the emissions of ammonia from buildings, during storage and during the grazing period), and it is projected to further increase to 68 million kg under *CAP-2000*, with *current nutritional management*. This increase of 15% is mainly due to manure from cattle and pigs. Changes on the excess amount of manure from poultry are negligible.

The application of *controlled nutritional management* reduces the excess amount of nitrogen from 68 million kg to 58 million kg (-15%). Using *potential nutritional management* the amount of nitrogen excess is reduced to 44 million kg. This is equivalent to a reduction of 35%.

Due to limitations on data availability, it is not possible to calculate costs to dispose of excess manure in Bretagne. However comparison of the conditions of the Netherlands with the situation in Bretagne, will allow an estimate of costs for the region of Bretagne. According to the situation in the Netherlands, about two-thirds of the excess amount of manure is distributed at a short distance from the holding. About one third of the excess amount of livestock manure is distributed at long distances. The distribution costs at short distances (including transport and storage) are about 6 ecu per tonne of manure (Luesink, 1993). Distribution costs at long distances (of approximately 150 km) are about 14.5 ecu per tonne of manure.

Table 7.3 The total costs to distribute excess amounts of manure in Bretagne based on conditions for the Netherlands

Scenario	Nutritional management	Distribution costs	
		total (million ecu)	per kg of excess nitrogen (ecu/kg N)
CAP-1994	current	45	0.76
CAP-2000	current	59	0.87
CAP-2000	controlled	55	0.95
CAP-2000	potential	48	1.09

Taking *controlled nutritional management* measures in Bretagne would reduce the disposal costs of excess of manure by about 4 million ecu (table 7.3). This is equivalent to a reduction of 7%. In case of *potential nutritional management*, these costs could be reduced by some 11 million ecu (18%). In case the costs for *controlled nutritional management* in Bretagne would be smaller than 4 million ecu, nutritional management would be beneficial in economic terms, compared with distribution of manure. The costs of *controlled nutritional management* in Bretagne are around 10 million ecu (calculated from the results of chapter 5). In this case *controlled nutritional management* is not beneficial at regional level, compared to the distribution of manure. Nutritional management however might remain beneficial to a large number of holdings, especially for intensive livestock producers with sufficient land to dispose of manure.

7.3 Options to dispose of excess manure in the Netherlands

In case of *CAP-1994* with *current nutritional management*, total nitrogen production from livestock manure in the Netherlands amounts to 654 million kg (table 7.4). This is equivalent to an average of around 325 kg N per ha. About two thirds originates from cattle, and the remaining part is from pigs and poultry. Excess amounts of livestock manure amount to 205 million kg of nitrogen. Almost 60% is accounted to pig production and some 30% to poultry production (table 7.5).

Any changes between *CAP-2000* and *CAP-1994* are due to (a) a reduction of livestock population, (b) nutritional management measures which contribute to a reduction of nitrogen from livestock manure, and (c) improved technical conditions (phase feeding). The decline of nitrogen production from cattle and poultry is almost completely due to a reduction of livestock production. The reduction of nitrogen production from pigs amounts to almost 30 million kg of nitrogen. About half of it results from a reduction of pig population. The remaining half is mainly due to nutritional management measures taken by livestock producers, allowing for better technical achievements and higher feed conversion rates by pigs. A comparison of *CAP-1994* and *CAP-2000* indicates a total reduction of nitrogen from livestock manure of some 126 million kg. This is equivalent to a reduction of almost 20%. Only a few percent of this reduction is due to nutritional management, because cattle have a share of some two thirds in the production of total livestock manure, and no nutritional management measures are considered for cattle.

Table 7.4 Nitrogen supply from livestock manure in the Netherlands (in million kg of nitrogen)

Livestock	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000		
Nutritional management	current	current	controlled	potential
Cattle	436	341	341	341
Pigs	149	120	105	97
Poultry	68	67	54	46
Total	654	528	500	484

Source: LEI.

In case of *CAP-2000*, the nitrogen content of manure from pigs and poultry is reduced by some 28 million kg by introducing *controlled nutritional management*. This is equivalent to 5% of the nitrogen production from total livestock and 15% of the nitrogen production from pigs and poultry. Compared to the case of *current nutritional management*, the supply of nitrogen from pigs and poultry could be reduced by some 44 million kg in case of *potential nutritional management*. This is equivalent to 8% of nitrogen production from total livestock, and 24% of total nitrogen supplied by pigs and poultry.

Table 7.5 Excess amount of nitrogen from livestock manure at farm level in the Netherlands (in million kg of nitrogen)

Animal type/disposal room	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with application standard		
Nutritional management	current	current	controlled	potential
Cattle	24	136	136	136
Pigs	119	108	92	84
Poultry	62	64	51	43
Total nitrogen	205	308	279	263
Manure (million tonnes)	19	35	35	35
Disposal room	285	113	114	114

Table 7.5 shows the assessments made at farm level regarding excess amounts of nitrogen from livestock manure, based on *application standard*. The disposal room is not fully used with *application standard*, which is mainly applicable for regions with extensive livestock production systems. Also important are limits on the application of phosphate which are more restrictive than limits on the application of nitrogen. Model assumptions, which are based on farming practices observed, consider part of the farmers remain to prefer using mineral fertilizers rather than organic nutrients.

Compared to *CAP-1994*, excess amounts of manure from cattle increase under *CAP-2000*, and the excess amounts produced from pigs even be slightly reduced. Excess amounts of nitrogen from cattle increase rapidly with the introduction of limits on the application of nitrogen (*application standard*). In that case the excess amount of nitrogen from cattle even exceeds the excess amount of nitrogen from pig manure. This difference between cattle and pigs mainly arises because most of livestock manure from intensive livestock producers presently already is disposed of according to current standards for application of livestock manure.

Table 7.6 shows the total amount of nitrogen produced from livestock in the Netherlands, and its disposal. Similar figures are presented for pigs and poultry in table 7.7. In case of *CAP-1994* with *current nutritional management*, most of the minerals supplied (almost 80%) are applied on the land, with processing and export of marginal importance. According to conditions in the Netherlands, standards on the application of nitrogen are very strict in the scenario of *application standard*. The application of nitrogen from livestock manure therefore is reduced by almost 50%.

Export of almost all manure from pigs and poultry (table 7.7) is not sufficient in meeting such standards on the application of nitrogen from livestock manure. Part of the manure from cattle also needs to be exported (8% of the total production in the case of *CAP-2000* with *controlled nutritional management*), because the available land resources are insufficient to apply all manure produced. The increase of excess amounts of manure from cattle is mainly due to the intensity of milk production in the Netherlands, which is the highest level of Europe (table 2.1). The Netherlands has many cattle farms with a stocking density which exceeds two cows per hectare. According to the limits formulated in the Nitrates Directive, a farmer may only apply the equivalent of approximately 1.5 cows per hectare. The intensity of cattle production in other regions of Europe is less intensive; the region of Bretagne, for example, is below that of the Netherlands.

Table 7.6 Production of nitrogen from livestock manure in the Netherlands according to processing and export, application and ammonia emissions (in million kg of N)

Process	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with application standard		
Nutritional management	current	current	controlled	potential
Processing and export	25	166	144	131
Emissions of ammonia	114	95	91	90
Application	515	267	265	263
Total	654	528	500	484

Table 7.7 Production of nitrogen from pigs and poultry manure in the Netherlands by category (processing and export, application and ammonia emissions) in million kg

Process	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with application standard		
Nutritional management	current	current	controlled	potential
Processing and export	23	138	115	103
Emissions of ammonia	55	36	32	29
Application	139	13	12	11
Total	217	187	159	143

Processing and export of manure as well as the emissions of ammonia all show the same trend in the different alternatives. They are all reduced by nutritional management. Nutritional management of nitrogen level however, has a minor influence on the application of nitrogen in the Netherlands because it is already in excess. Taking nutritional management of nitrogen output generally contributes to a reduction of the export of nitrogen from livestock manure. Therefore the nutrients applied abroad from livestock manure produced in the Netherlands will be reduced. Processing and export of livestock manure generally also are far more expensive options to dispose of excess manure compared to options to apply livestock manure (see also section 7.4).

A precise estimation of the nitrogen content of the manure by processing, export and application (table 7.7) is complicated because of the emissions of ammonia. The models used distinguish between various types of emissions, including the emissions from buildings, during storage of manure, emissions during grazing of livestock and emissions during land application of livestock manure. The models do not consider the emissions of ammonia during processing, export or distribution. In this report the emissions of ammonia are assigned to the amounts of manure which are distributed, exported or processed.

Table 7.8 Amount of nitrogen applied at the own farm, distributed by short and long distances in the Netherlands, in million kg

Transport distance	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with application standard		
Nutritional management	current	current	controlled	potential
Own farm	408	159	155	152
Short distance	61	61	61	61
Long distance	46	47	49	50
Total	515	267	265	263

Table 7.8 shows the amount of nitrogen applied in the Netherlands according to different options available. The prevailing standards on the application of nitrogen from livestock manure largely affect the amount to be applied. The total amount of manure which is distributed at short and long distance remains generally stable at a level of around 100 million kg of nitrogen. The level is 110 million kg for the scenarios with the *application standard*, whereas it is 100 million kg with the *CAP-1994* scenario.

The distribution of nitrogen from livestock manure is very high with the *application standard*. This is due to the types of manure which need to be distributed. Almost all manure which needs to be distributed in these scenarios originates from cattle. In comparison, with *CAP-1994*, part of the manure to be distributed also originates from pigs.

7.4 Costs to dispose excess of manure in the Netherlands

Table 7.9 provides an assessment on the costs to dispose excess of manure, either by distribution (through means of short and long distances), export and processing. This table shows that costs remain stable by comparing *current* with *controlled* and *potential nutritional management*. Total costs are a few percent lower in case of nutritional management measures taken which go beyond current practice. The reason for this small difference is the major cost factor arising from the volume of livestock manure produced. Costs for distribution and processing depend on volumes of manure to be distributed or processed, which is considered to remain constant in the calculations made. A reduction on the nitrogen content in that case has a marginal impact on the costs to distribute and process excess amounts of manure.

The amount of manure which needs to be distributed in the Netherlands differs across livestock category, and also depends on the prevailing standards to apply livestock manure. Measures to limit the application of nitrogen are costly, because of the high distribution costs involved (table 7.9).

Table 7.9 Costs to dispose excess amounts of manure according to the various scenarios (total costs in million ecu, and per m^3 and per kg of nitrogen in ecu)

Type of costs	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with application standard		
Nutritional management	current	current	controlled	potential
Distribution	178	217	219	220
Export and processing	11	422	415	412
Total	189	639	635	632
Per m^3	9.90	18.09	18.00	17.95
Per kg N	0.92	2.07	2.28	2.40

The amount of export and processing costs is dependent on the amount of manure (volume, in m^3) which needs to be processed or exported. About one third of total manure production is processed or exported in case of the *application standard*. There might be political and social constraints for such conditions because the costs involved are very high. Processing and export of large amounts of livestock manure are considered to be very costly (table 7.9) and might even imply that the number of pigs and poultry would be reduced. Major costs however also would be involved with structural measures to reduce livestock population. By comparison with the extra costs (36 million ecu) of *controlled nutritional management* (decline of protein level in compound feed for pigs from 16.5 to about 14.5%) (calculated from the results of chapter 5) with cost savings achieved to dispose of excess manure (4 million ecu), we may conclude that *controlled nutrition management* is too costly under such conditions. This also implies that extra nutritional management measures would be insufficient to reduce nitrogen pollution. Policies with standards on the application of livestock manure, deriving from the Nitrates Directive, would largely affect pig production. Therefore, *controlled nutritional management* and *potential nutritional management* will contribute to smaller reduction in pig population compared to the case of *current nutritional management.*

7.5 Disposal of excess manure in the Netherlands with a policy targeted on nutrient balances

Conditions in the Netherlands are rather extreme compared to elsewhere in Europe. All means of structural and technical measures must be combined to alleviate the nitrogen pollution burden and bring it down to acceptable levels. In this section an assessment is made of the disposal of excess manure with a policy which is targeted on nutrient balances.

In case of *mineral balances* the excess amounts of nitrogen from livestock manure are substantially lower than in case of the scenario of *application standard* (table 7.10 compared with table 7.5). Policies with *mineral balances* and the use of *controlled nutritional management* reduce the excess amount of nitrogen from 218 million kg to 192 million kg of nitrogen (a reduction of 12%). The excess amounts of nitrogen reduce from 308 million kg to 279 million kg under the scenario with limits on the application of nitrogen (a reduction of 9%). By making use of *potential nutritional management* in compound feeds the excess amount of nitrogen is reduced to a level of 180 million kg (*mineral balances*) or 263 million kg (*application standard*). The percentage rates of reduction in these cases are 17% (*mineral balances*) and 15% (*application standard*).

Table 7.10 Excess amount of nitrogen from livestock manure at farm level in the Netherlands (in million kg of nitrogen)

Animal type/disposal room	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with mineral balance		
Nutritional management	current	current	controlled	potential
Cattle	24	55	55	55
Pigs	119	101	87	82
Poultry	62	63	50	43
Total nitrogen	205	218	192	180
Manure (million tonnes)	19	20	20	20
Disposal room	285	205	205	205

Nutritional management only has marginal impact on the amount of manure which needs to be processed. The amount of manure processed (volume in m^3) with *CAP-2000* and *mineral balance* (*current nutritional management*) equals 4.9 million tonnes. It equals 4.7 and 4.6 million tonnes with *controlled* and *potential nutritional management* respectively. Table 7.11 shows the total amount of nitrogen produced from livestock in the Netherlands, and the methods of disposal. Similar figures are also presented for pigs and poultry in table 7.12. In case of *mineral balance* the application of nitrogen from livestock manure is around 30% above that with *application standard* (table 7.11 compared with table 7.6). Similarly, processing and export of livestock manure (*mineral balance*) is about half the level of *application standard*. The scenario for *mineral balance* applies more manure from pigs and poultry compared to the case of *application standard*.

The three processes (processing and export of manure, emissions of ammonia and application of manure) all are reduced by nutritional management measures. Nutritional management of nitrogen however mainly contributes to a reduction of the export of nitrogen from livestock manure (table 7.11). Main cost savings to dispose of excess manure could be achieved by reducing the manure which needs to be processed or exported.

Table 7.11 Production of nitrogen from livestock manure in the Netherlands according to processing and export, application and ammonia emissions (in million kg of N)

Process	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with mineral balance		
Nutritional management	current	current	controlled	potential
Processing and export	25	76	62	54
Emissions of ammonia	114	106	101	98
Application	515	346	337	332
Total	654	528	500	484

Table 7.12 Production of nitrogen from pigs and poultry manure in the Netherlands by category (processing and export, application and ammonia emissions) in million kg of N

Process	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with mineral balance		
Nutritional management	current	current	controlled	potential
Processing and export	23	74	60	52
Emissions of ammonia	55	47	41	37
Application	139	66	58	54
Total	217	187	159	143

Comparing *mineral balance* with *application standard* (table 7.8 and table 7.13) shows that transport of manure differs to a limited extent only. Main differences arise on the application of livestock manure at the own holding. The amount of manure which could be applied at the own holding is increased by some 100 million kg of nitrogen by a system based on mineral balances compared to the *application standard* which arises from the Nitrates Directive.

Differences in distribution costs between the scenarios with *mineral balances* and *application standard* arise due to source of manure which needs to be distributed. In the scenarios with the application standard (table 7.9) almost only manure from dairy cattle is distributed and by the scenarios with mineral balances pig manure is also distributed (table 7.14). Pig manure distributes more phosphate and nitrogen per m^3 than that of cattle, because of the lower mineral content of manure from cattle. Distribution costs to dispose of excess manure, therefore, are higher for the *application standard*, since it results in more manure being distributed.

Table 7.13 Amount of nitrogen applied at the own farm, distributed by short and long distances in the Netherlands, in million kg

Transport distance	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with mineral balance		
Nutritional management	current	current	controlled	potential
Own farm	408	256	247	240
Short distance	61	50	50	52
Long distance	46	40	40	40
Total	515	346	337	332

Table 7.14 Costs to dispose excess amounts of manure according to the various scenarios (total costs in million ecu, and per m^3 and per kg of nitrogen in ecu)

Type of costs	Agricultural policy and nutritional management			
	CAP-1994	CAP-2000 with mineral balance		
Nutritional management	current	current	controlled	potential
Distribution	178	159	161	162
Export and processing	11	131	126	123
Total	189	290	287	285
Per m^3	9.90	14.35	14.18	14.05
Per kg N	0.92	1.33	1.49	1.58

7.6 Concluding remarks

1. The manure market of Bretagne differs from the Netherlands. The supply of nitrogen from cattle and poultry manure is only about half of that in the Netherlands. The total supply of pigs manure is some 25% below that of the Netherlands. In the Netherlands, the excess amounts of nitrogen from livestock manure is more than three times larger than in Bretagne. Such conditions do not prevent the land application of all excess manure, and part of it has to be exported and processed. However, Bretagne has sufficient disposal room to apply all excess livestock manure. Export and processing of manure is not required in that region, according to current livestock production and prevailing legislation.
2. Excess amounts of nitrogen from livestock manure in Bretagne are substantially below that in the Netherlands. About half of the pig manure could be applied at the holding in the region of Bretagne, compared with 10 to 20% in the Netherlands. Expensive curative measures need to be taken in the Netherlands to dispose of excess manure. Up to about

one third of livestock manure may have to be processed and exported in that country. Some disposal room remains left in Bretagne. However, a limited amount of livestock manure (6 million kg of nitrogen or 2% of total manure produced) may have to be exported or processed in case of strict legislation.

3. All manure can be applied within the region of Bretagne when *controlled nutritional management* measures are taken. In case of *potential nutritional management*, there is room left in Bretagne to apply the equivalent of an extra 22 million kg of nitrogen.
4. All means must be combined to alleviate nitrogen pollution problems from intensive livestock production in the Netherlands. A scenario for mineral balances apply more manure from pigs and poultry compared to the application standard. The amount of manure applied at the own holding is increased largely by a system based on mineral balances compared to the application standard. Distribution costs to dispose of excess manure therefore are lower for the mineral balance.
5. Linkages between nutritional management measures and nitrogen pollution from livestock manure are a crucial element of pig production. They have not been assessed in the scope of this study, because this would require mineral balances at regional level. Mineral balances require all relevant nitrogen flows at regional level, including mineral fertilizers. These have not been assessed in the framework of this effort.

8. Options for policy and research: concluding remarks

8.1 Introduction

The objective of this report is to evaluate the relative economic and environmental benefits of the available options to reduce nitrogen pollution from livestock production units in Europe within the context of the changing CAP regime and the Nitrates Directive. Emphasis has been given to the role of nutritional management of intensive livestock production as an option of reducing sources of pollution by adjusting the nutritional management of livestock production systems. The objective of the present chapter is to synthesize the major conclusions of the report, and to explore options for policy and research in an effort to reduce nitrogen surpluses from livestock production systems in Europe by nutritional management. The major findings of the study are summarized in section 8.2; recommendations for policy, research and monitoring are given in section 8.3.

8.2 Major findings

1. *Nitrogen pollution problems from animal farming are a major environmental risk in areas with intensive livestock production; nitrogen surpluses are highest at pigs and poultry farms (chapter 2).*
   Nitrogen pollution problems from agriculture constitute a major threat to the quality of the European aquatic environment (groundwater, surface waters and marine waters). Risks primarily relate to the high levels of nitrates in available drinking water resources, eutrophication of surface waters and coastal waters and acidification of soils and waters. Intensive livestock production is one of the main sources of nitrogen pollution, due to excessive amounts of livestock manure in comparison with available agricultural lands.

   Nitrogen surpluses are the precursor of nitrate leaching into the water. Regions with nitrogen surpluses exceeding 100 kg per ha are considered to be vulnerable to nitrate leaching. The resulting pollution level of groundwater and surface waters however depends on soil and climatic conditions.

   Nitrogen surpluses exceed 100 kg/ha on some 22% of EU agricultural land. Intensive livestock production and related nitrogen pollution is concentrated in the Netherlands and Belgium where nitrogen surpluses even exceed 200 kg N/ha (2% of the agricultural land in the EU), Denmark, Germany (Schleswig-Holstein, Niedersachsen, Nordrhein-Westfalen, Bayern), Southern part of the United Kingdom, Western part of France (Bretagne), Cataluna in Spain and the Po Valley in Italy. In these regions, livestock manure is the most important factor determining nitrogen surpluses.

   Nitrogen surpluses are observed to be most critical on pig and poultry farms as a result of their high stocking density compared to the nitrogen requirements of the available farm land. The feed, and more specifically, protein concentrates (such as soyabean meal) supplied to these holdings originate mainly from external sources. Ruminant farms, although producing large quantities of slurry in absolute term, have not so much impact on the environment since the grazing land area contribute to a better balance with excreted nitrogen.

2. *Some Member States have developed nutrient balances. Reduction of nitrate pollution within the EU resulting from policies implemented by Member States is falling short of the target assigned by the Nitrates Directive (chapter 3).*
   With the adoption of the Nitrates Directive in 1991, the EU has initiated and driven the actions of Member States toward control of pollution from animal farming. In this framework, Member States have formulated policies providing incentives to reduce pollution by improving farming practices and adjusting farm structures. In addition, actions have been taken to achieve a balance between input and output flow from agricultural sources, including transport and treatment of livestock manure. Among these, various types of mineral bookkeeping systems are proposed in several Member States in an effort to keep their mineral surpluses under control. But the impacts of such measures remain below the potential opportunities provided by these systems to reduce pollution at source. However, differing national policies lead to a non-coherent approach which are partially not in compliance with the Nitrates Directive.
3. *Nutritional management reduces nitrogen output by 20 to 25% (chapter 4).*
   Nutritional management plays a key role in reducing nitrogen pollution at source. High nitrogen excretion is a direct consequence of dietary protein being fed far above animal requirements. Protein level in feeds can be reduced by providing feed more closely allied to the animals requirements without affecting its performance (phase feeding and balanced dietary protein levels), resulting in a reduced nitrogen excretion by animals. This well-known technology does not require large additional investments. It is flexible and can be adjusted to the nitrogen-reduction targets. Nutritional management allows for a 20 to 25% reduction of nitrogen excretion in pigs and 15 to 35% reduction in broilers respectively.

   Several regions have undertaken measures along these lines, but insufficient involvement from the animal production sector being concerned by the uncompensated increase of feed cost, combined with a lack of steering at European level have limited a wider implementation of environmental friendly feed formulations.
4. *CAP reform provides an opportunity for cost effective nitrogen output reduction from livestock production through a reduction in the costs of compound feed (chapter 5)*
   Feed formulas are generally calculated by computer programs to meet a set of nutritional constraints at the least possible cost per tonne. Least cost formulas do not automatically correspond to the most environmental friendly feeds. The main factor influencing the costs of a reduction of the protein content in feed is the difference between the grain and protein-based-feedstuffs prices (e.g. soyabean meal). Through a reduction of the cereal intervention price, the CAP reform has consequently a direct and positive impact on the economical feasibility of environmental friendly feeds. CAP reform improves the economic margins in the livestock production sector. This enables the sector to apply controlled nutritional management without compromising profitability of operations.

The CAP reform implemented from 1992 to 1995 significantly reduced the cost of lowering the protein content of compound feed. However, taking into account average prevailing protein prices, benefits derived from lower grain prices in EU under the 1992 CAP reform were not high enough to induce significant switches in formulation from high to low dietary protein diets. Moreover, the 1992 CAP reform pushed specifically the use of wheat. Due to the unbalanced amino-acid profile of wheat, however, the consequence was a further increase of the protein level in least cost formulated feeds. An imbalanced amino acid profile of wheat however can be compensated for by crystalline amino acids.

5. *Small incentives complementary with the CAP reform will lead to a major shift toward environmental friendly formulation practices (chapter 5).*

As a result, the 1992 CAP reform reduced the cost of feeding measures alleviating the pollution burden in livestock areas, but, at best, only stabilised the pollution load, and at worse further increased it under an average commodity environment. In other words, the 1992 CAP reform facilitated nitrogen pollution control but did not achieve it. However, appropriate incentives would allow inducing a large shift toward environmental friendly formulation practices. The role of CAP reform in reducing nitrogen pollution exceeds that of nutritional management.

The upcoming new CAP reform is expected to further provide for a wider application of low protein feeds. However, in absence of specific regulatory mechanisms, the dietary protein level and related nitrogen output will remain uncontrolled and driven by the highly volatile world market price of protein sources. Hence, there is no certainty that feeding programs will automatically be adjusted for lower nitrogen excretion without necessary initiatives.

Any beneficial effects of CAP on nitrogen pollution control may be jeopardised by a volatile soya market. Soyabean meal prices however play a very significant role in nutritional management measures which go beyond current practice. The price of soyabean meal also affects the price of other protein-rich material. Any change of world market prices of soyabean meal may therefore influence the effectiveness of using CAP reform measures to manage nitrogen pollution.

6. *Practical application of nutritional measures represents a cost effective alternative at farm level (chapter 6).*

Introduction of nutritional management also depends on the cost of alternative measures, including costs to dispose excess manure. Disposal cost are likely to further increase in the years to come in response to more stringent rules on the application of livestock manure. Besides, marginal treatment costs sharply increase with the scale of the surplus volume. An increase of disposal cost will support the introduction of better nutritional management.

Preventive nutritional management to reduce nitrogen output at farm level is economically competitive compared to downstream processing of excess manure (storage, transportation and treatment). This mainly applies to pig and poultry farms which nowadays dispose of large amounts of livestock manure. Pig and poultry holdings with sufficient land to apply animal manure may achieve a balance between the extra feeding costs and the cost savings on the distribution of livestock manure.

7. *Nutritional management is a realistic option to avoid the need of excess manure disposal at regional level (chapter 7).*
In most regions of Europe with intensive livestock production, the application of only adequate nutritional management will eliminate the need for additional costly treatment of farm effluents. For instance, under the current situation, only about half of the pig manure could be applied at holdings in the region of Bretagne without exceeding a nitrogen level per hectare as imposed by the Nitrates Directive. However, by applying adequate feeding measures, the total amount of manure produced could be disposed of without violating the Nitrates Directive. With best technical nutritional management there would even be room left in Bretagne to apply an additional 22 million kg of nitrogen corresponding to 20 % of current pig population. Regions with high levels of pigs and poultry in Europe like Denmark, parts of Germany, Cataluna and Lombardy have excess levels of manure which are similar with those of Bretagne.

The implementation of the Nitrates Directive is likely to provide an incentive to nutritional management measures with reduced protein diets in regions like Bretagne. This applies especially to holdings with sufficient land to apply livestock manure. Pig holdings with more than 15 ha of agricultural land may achieve a balance between the extra feeding costs and the cost savings on the distribution of livestock manure.

In regions where the manure situation is more severe, nutritional management alone is insufficient. In effect, all means (structural and technological) must be combined to alleviate the pollution burden and bring it down to an acceptable level. In the Netherlands, only 10 to 20% of the pig manure can be applied on the holding within the limits set by the Nitrates Directive. As a consequence, a large part of it must be processed and/or exported at a high cost. In these regions, nutritional measures even prove to be more advantageous. Reduction of part of the excess manure will dramatically reduce the marginal elimination cost of the remaining surplus.

8.3 Recommendations for policy, research and monitoring

1. *Nutritional management should be the primary tool for controlling excess nitrogen from intensive livestock production and meet the targets of the Nitrates Directive.*
Efforts in meeting the Nitrates Directive requirements should go beyond the means of livestock manure application (good farming practices) and treatment. Priority should be given to systems which provide incentives to reducing the pollution at source. Adjustment of animal production structures, especially toward lower livestock density, is an option, but it is costly and slow to show concrete results. In the meantime, preventive rather than curative measures with immediate effects and minimum economical burden should be enforced in synergy with structural changes.

From this study, it becomes increasingly clear that the treatment of pollution at source is an important tool of choice when aiming to comply to the Nitrates Directive. Technological advances on both animal genetics and nutrient availability have resulted in significant progress in the provision of environmental friendly feeding systems over recent years.

Baring notable exceptions, nutritional management is not well understood outside the core of nutritionists of the animal feed sector. Its potential benefits are underestimated or even totally overlooked. For historical reasons and because it seemed to be an obvious approach, treatment of excess manure has received the most attention from authorities and decision-makers compared to the option of reducing pollution at source.

2. *A consistent approach on regulatory initiators in the field of nutritional management should be established at European level.*

Various regulatory initiatives in the field of nutritional management have already been taken in several Member States in an attempt to curb the increasing level of nitrogen pollution, but these remain of too limited scale and show insufficient participation from the animal farm sector.

Three approaches have been put into practice:

1. Mineral book keeping systems monitor the input and output flows of nitrogen at farm level in order to quantify the amount of nitrogen applied on the land, which exceeds the limits as defined by the Nitrates Directive. The calculated surplus is then used as a parameter for the calculation of an environmental taxation and/or incentive.
2. The standard system relying on a predefined and standardized set of nutritional specifications including limited and controlled dietary protein levels per type of formula ('green feed label'). The participation to the scheme may allow for maintaining the herd size on farms.
3. Investment subsidies to pig and poultry farms to upgrade feeding equipment and allow changing diets in line with requirements of growing animals (phase feeding).

Legislation should facilitate the introduction of controlled nutritional management by giving incentives to the livestock sector, such as the three approaches mentioned before.

The scope of these regulatory tools should be extended to all Member States, but especially to those regions which are classified as being vulnerable, through:

1. Support from European level to harmonise the regulatory systems and contribute to consistency and equilibrium between Member States.
2. Information platform between regions and Member States to exchange and transfer know-how on regulatory and administrative systems and exchange experience regarding concrete implementation at administration level (Water Authorities, Ministries of Agriculture and Environment, Commodity Board Trade Associations...).
3. Improved communication with decision makers on the potential reduction of pollution levels achievable through nutritional management.
4. Set up of pilot operations to validate technical and economical aspects and test administrative procedures.

3. *Adequate incentives should be put in place to make the nutritional measures operational and effective.*

High participation of the animal sector in these schemes is crucial. Costs to dispose of the remaining excess amounts of manure can only be reduced if a large share of pig and poultry holdings take nutritional management measures, allowing for a reduction of the overall environmental bill. Large adhesion from the animal sector requires:

1. Strong political will from authorities at European, national and regional level.
2. A framework of regulatory and financial incentives that reward at every level the reduction of pollution achieved by participating in the pollution-reducing scheme. Linkages need to be created between agricultural policy, environmental policy including taxes, and nutritional management.

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Appendix A CCM-model

A.1 Introduction

The Cereal and Compound Feed Market model (CCM-model) is a regionalized multi-commodity model of cereal and compound feed raw material. The model covers only EU-12 (Blom, 1995). It is a partial equilibrium model to assess medium-term effects (up to five years ahead) of agricultural policies on supply and demand of cereals and compound feed raw material. A distinction is made between 24 regions across EU-12 (figure A.1). The model covers grain, oilseeds and cereal substitutes and provides insight in the medium-term development on production of grain and oilseed, as well as the demand for compound feed. The model provides assessments regarding the consequences of the CAP reform on the demand for arable crop products. The CCM-model also allows to provide assessments on changes in prices of compound feed as well as the protein content in compound feed, in response to changes in agricultural policy, either at Community, national or regional level.

The model was developed at the time of the original EU-12, during the mid eighties when the EU production of cereals exceeded the consumption. By that time the EU became a net exporter of cereals. Another reason to develop this model has been the increasing societal interest in the consumption of cereals and cereal substitutes to feed the intensive livestock sector. Figure A.2 provides an overview of the modules of the CCM-model. Arrows show the order of the calculations. The first module contains the calculation of the regional cereal prices in national currency. This module is further explored in section A.2. After the calculation of cereal prices both the supply of agricultural products as well as the demand of cereals can be calculated. The supply of arable products, including cereals, is modelled with a translog gross revenue function (module 6). Consequences for income of arable farmers (module 7) and budget of the EU (module 8) can be calculated thereafter. The right-hand side of figure 2 shows the demand of cereals for compound feed, human consumption, industrial uses, seed and on farm direct feed (module 2-5). The thick lined block around linear programming of compound feed, the demand of compound feed and the supply of raw materials is handled in section A.3. Based on the prices of compound feed the competition of intensive livestock production between different regions can be calculated (module 10). The impact of changes in cereal and compound feed market and in the cost structure of intensive livestock production for consumers and intermediate users are assessed in module 9.

Chapter 5 was only based on the modules 1-4. Other modules are not necessary for calculations made in the report, and therefore are not described in further detail.

A.2 The cereal prices

In the first module the cereal prices are calculated. Based on the intervention price of cereals, which are decided by the Council of Ministers, regional prices in national currency are calculated for six crops: wheat, barley, rye, oats, maize and other cereals. For each cereal crop an average price (average between cereals used for human consumption and for feed) and a feed consumption price are calculated. Such data derive from a detailed investigation in the EU on regional market prices of different cereals in the period 1985/86 - 1989/90, and trends on prices in relation with the intervention price. Data about exchange rates are necessary to switch from the intervention price in ecu to a national currency. This module provides two tables of cereals prices, for 6 cereals and 24 regions each of them containing a price in national currency. One table with the average price for cereals, which is used in the arable crop supply module. The second table with feed use prices of cereals is used in the linear programming of compound feed. The intervention price is an important tool in the CCM-model. Variation of this intervention price, introduced with the reform in 1993 of the CAP, could have substantial consequences for the market prices in the EU regions and the demand of cereal raw material for compound feed.

A.3 The linear programming

Modules 2, 3 and 4 allow to assess the least possible costs for compound feed, given the prices of raw materials and the technical constraints. For each of the 24 regions, 9 compound feeds are identified with regional prices (free on board (fob) autumn of the specific crop year) and regional specified constraints (module 2). The specifications of the models are close to the formulation practices in the Dutch compound feed industry. Regional demand of compound feed per animal category is based on the demand for meat, dairy products and eggs (module 3). The supply of mainly imported concentrates (module 4) is described by 'net excess supply'-functions. The price elasticity of the 'net-excess supply'-function is, among other reasons, determined by the share of the EU compound feed industry in the total demand for a raw material. It can be shown, ceteris paribus, that the price elasticity of the 'net excess supply' function gets lower with an increase of the share of the EU compound feed industry in total demand. The price elasticities of these function are based on an analyses of the 'net excess supply' function and a number of assumptions about supply elasticities for the different raw materials and the demand of other buyers outside the EU compound feed industry.

The CCM-model comprises 47 different commodities:
- 6 cereals (wheat, barley, rye, oats, maize and other cereals). Prices of these commodities are instrument variables; quantities are defined endogenously;
- 9 important compound feed raw materials (soyabean meal, maize gluten feed, tapioca, beet pulp, citrus pulp, brans, rapeseed meal, sunflower meal and peas). Prices and quantities of these compounds are both defined endogenously;

- 25 feed raw materials of relatively small importance (i.e. beans, other oilseed meals). Their prices are considered to depend on the price of a comparable important raw material, and quantities are based on historical information about the usage;
- 7 additives (of which four amino acids, including methionine, lysine, threonine and tryptophan). Prices of these products are fixed and quantities can vary within a limited range.

The CCM-model optimizes 9 different compound feeds:
cattle: - high protein feed for dairy cattle;
- low protein feed for dairy cattle;
- feed for beef cattle;
pigs: - piglets or protein concentrate;
- sows;
- finishing pigs;
poultry: - growers;
- layers;
- broilers.

In region 1 (the Netherlands) and 24 (Portugal) a compound feed for piglets is assumed because of the low direct grain use, while in the other regions a supplementary protein concentrate is assumed. For a more detailed description about the specifications of the compound feed see Blom (1995, pp.109-118).

Table A.1 provides some detail on the specification of compound feed for different animal types.

Table A.1 Specification of compound feed for different animal types

	Pigs		Poultry		
	sow	finishing pig	growers	layers	broilers
Energy value (EW)	>0.97	>1.03			
Energy value (OMEN)			>2,800	>2,800	>3,150 a)
Protein (g/kg)	130-180	>145	150-180	150-180	185-230
Fat (g/kg)	< 55	10 - 65	> 0	> 0	> 0
Fibres	< 90	40 - 60	> 0	> 0	> 0
Lysine	>0.60	>0.72	>0.58	>0.61	>0.92
Methionine			>0.27	>0.29	
Methionine-cystine	>0.40	>0.47	>0.50	>0.57	>0.70
Threonine	>0.50	>0.47		>0.41	
triptofaan	>0.13	>0.14		>0.13	

a) 3,150 for the Netherlands, slightly lower in the other regions of the EU.
Source: CCM-model LEI.

A.4 Initial prices of important (non-cereal) raw materials

Initial prices of the important (non-cereal) raw materials are required as an input to the linear programming procedure. After the first iteration of the linear programming new prices are calculated on the basis of supply and demand for those raw materials.

The supply of the important compound feed raw materials is described by 'net excess supply' functions. The price elasticity of the 'net' excess supply'-function is, among other causes, determined by the share of the EU compound feed industry in the total demand for a raw material. A more detailed description of these items is discussed in Blom, 1995, pp. 70-76.

The initial prices are based on statistical information of wholesale retailers prices in The Netherlands. It was assumed this also to be applicable to the other Member States of the EU.

As shown in table A.2 the raw material prices of the energy rich products (tapioca, brans) was reduced by the year 1994/95 compared to the period before the reform of the arable crop regime. Two exceptions are beet pulp and citrus pulp since their prices increased during that period. The price of protein rich feedstuffs (e.g. soyabean meal, rapeseed meal and sunflower meal) increased in the same period. Especially soyabean meal became more expensive and has nowadays (autumn 1996) a very high price. Such high prices of soyabean meal reduce competitive position of the raw material market.

Table A.2 Initial prices of the important (non-cereal) raw materials in 1990/91 and in 1994/95 (ecu/tonne)

Raw material	1990/91	1994/95
Soyabean meal	167	170
Maize gluten feed	125	123
Tapioca	155	137
Beet pulp	129	141
Citrus pulp	118	124
Brans	119	109
Rapeseed meal	108	119
Sunflower meal	103	109
Peas	170	165

Source: LEI databank PRIMAVERA.

A.5 The price changes of compound feed

The percentage change of the feed concentrate price of different animal species compared to the *CAP-1988* price are presented per region in table A.2. The percentage price change of feed concentrates as a result of reduced crude protein levels in feed concentrates is also presented in table A.3.

CAP Reform reduces the price of feed concentrates about 17 to 19% in the regions assessed. An exception to this is Cataluna, the price of feed concentrates increases about 9 to 11% as a results of a considerable inflation in Spain.

The even higher reduction in the price of feed concentrates under *CAP-2000* is mainly the result of the 10% reduction in the intervention price level of cereals, which is assumed by the assessment of the CCM-model.

In general a lower crude protein level increases the price of feed concentrates because the composition of feed concentrates is subject to an additional constraint. However, the price change of feed concentrates as a result of a reduced crude protein level does not only depend on the change of the composition of the feed concentrate but also on the price of the different components. In case lower levels of crude protein are used, the demand for crude protein will decrease and consequently the price of crude protein will decrease. The price of feed concentrates with relatively high crude protein levels, like broiler feed, will be lower.

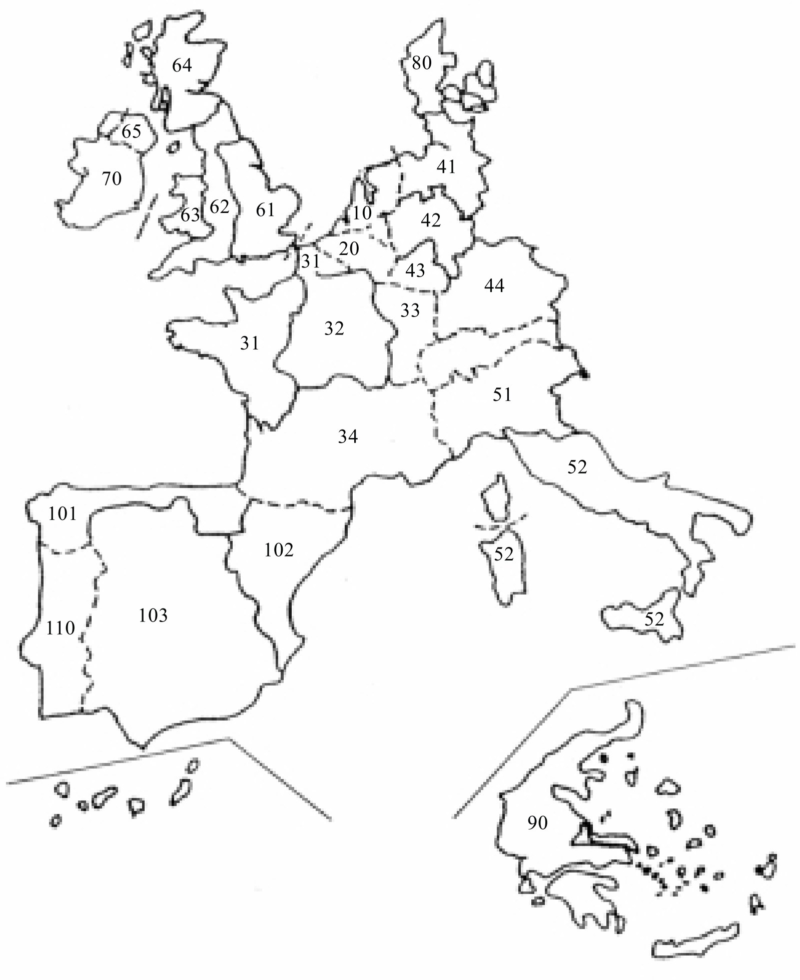
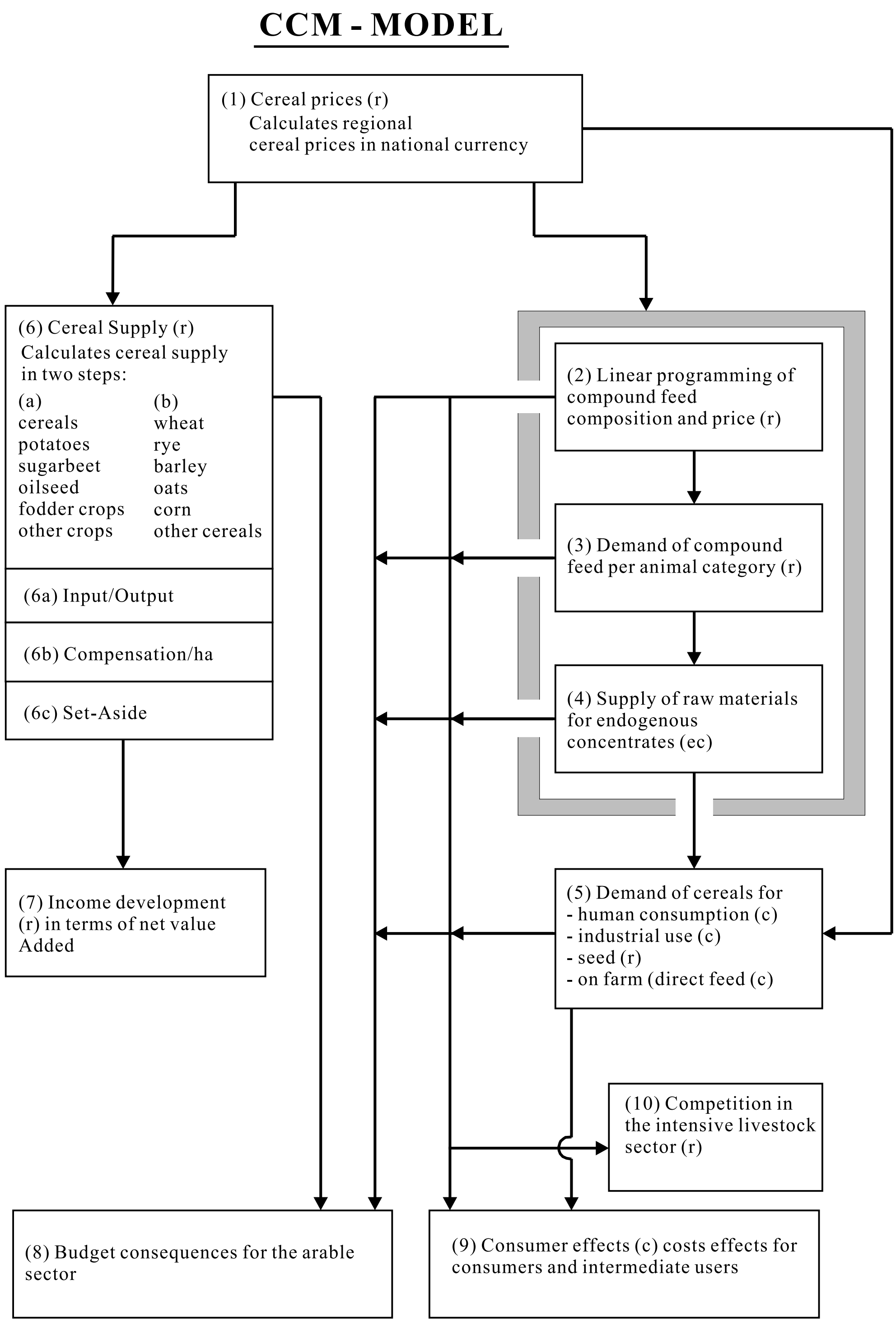


Figure A.1 Regions distinguished in the CCM-model
Source: Blom (1995).



Legenda:

(1) - (10) : module numbers
r, c and ec: the module generates endogenous variables on regional, country or EC level

Figure A.2 Modules of the CCM-model

Table A.3 Percentage change in the costs of feed concentrates of different animal species compared to the 1990/91 situation and percentage price change as a result of lower crude protein levels in feed in the regions

		Price change (%) compared to CAP-1988				Price change (%) as a result of a lower crude protein level		
Scenario		CAP-1994		CAP-2000		CAP-1988	CAP-1994	CAP-2000
Nutritional management		current	controlled	current	controlled			
Belgium	breeding sows	-18.6	-16.5	-36.5	-35.9	3.3	2.6	0.9
	pigs for finishing	-18.2	-15.1	-36.4	-33.9	4.6	3.8	3.9
	laying hens	-18.0	-17.7	-34.8	-34.6	0.5	0.3	0.3
	broilers	-17.9	-18.0	-34.1	-34.2	-0.1	-0.2	-0.1
Denmark	breeding sows	-16.8	-14.3	-32.0	-31.3	3.5	2.9	1.1
	pigs for finishing	-18.5	-15.2	-33.5	-31.2	5.6	4.0	3.4
	laying hens	-18.2	-17.1	-32.4	-31.6	1.3	1.4	1.2
	broilers	-16.8	-17.1	-31.0	-31.1	-0.3	-0.4	-0.1
Cataluna	breeding sows	9.5	11.4	-18.7	-18.4	2.2	1.7	0.3
	pigs for finishing	9.5	13.8	-18.0	-13.6	4.4	3.9	5.4
	laying hens	11.0	11.3	-14.0	-13.8	0.6	0.2	0.2
	broilers	11.4	12.1	-12.4	-11.7	0.9	0.6	0.8
Bretagne	breeding sows	-19.4	-17.8	-36.2	-35.8	2.5	2.0	0.6
	pigs for finishing	-18.6	-14.3	-34.7	-31.8	5.3	5.3	4.4
	laying hens	-17.4	-16.5	-33.2	-33.0	1.3	1.1	0.3
	broilers	-17.8	-18.3	-33.3	-33.4	-0.4	-0.6	-0.2
Netherlands	breeding sows	-18.2	-15.6	-32.5	-31.2	3.9	3.2	1.9
	pigs for finishing	-17.9	-12.4	-31.5	-28.2	7.9	6.6	4.9
	laying hens	-18.3	-16.1	-33.7	-31.9	3.3	2.8	2.7
	broilers	-17.6	-16.9	-30.1	-29.7	1.0	0.9	0.7

Source: CCM-model results LEI.

Appendix B FEM-model

Introduction

The Farm European Mineral Model (FEM-model) was developed in 1995/96 for a contribution to the study 'Standards on nitrate in the European Community: Processes of change in policy instruments and agriculture'. The farm level model has been operational to assess the impact of the application standard of the Nitrates Directive on EU agriculture. The model covers 12 EU Member States (the Neue Bundesländer in Germany have not been included) and can be assessed for all kind of farming types.

Method and assumptions

The FEM-model is a farm-level Linear-Programming-Model (LP-model). The LP farm model is of the standard LP format, with the production process approximated using linear constraints. The objective function, which maximises whole farm gross margin including net subsidies, provides an indicator for the change in farm income. The impact on the environment is indicated by the change of the mineral balance, which is calculated endogenously in the model. The farm model can be characterised as a comparative static LP-model. It is a pure supply model. Macro-effects are not considered. Environmental elements are introduced as model constraints. For example the maximum amount of nitrogen from animal manure allowed to be applied. The mathematical form of the linear programming problem is:

$$\text{Maximise } \{Z = c'x\} \qquad (1)$$
$$\text{subject to } Ax \leq b$$
$$\text{and } x \geq 0$$

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

Mineral balances

The impact of policy on the environment is indicated in the model by the change of the mineral balance. Mineral balances are tools to provide insight into flows of nitrogen across agriculture. A so-called soil surface balance approach has been applied to assess mineral balances at farm level. The components considered include input as well as output components. Inputs are the total amount of nitrogen from mineral fertilizer, animal manure and deposition from the atmosphere, outputs are the uptake of nitrogen from harvested crops and losses of ammonia during storage and spreading.

Adaptation possibilities

The optimisation approach used in the model (Linear Programming) allows to simulate the response of individual producers to policy in terms of flows of organic manure. Farms can dispose and purchase organic manure. Only a limited set of adjustment possibilities is considered in the model to keep comparison between scenarios as clear as possible. For example the observed area of land per farm places a fixed physical limit on the land available for spreading. Granivore farms with only one hectare of land and a high excess per hectare could otherwise halve the excess by buying or renting another hectare of land. Whereas the total area of land available for agricultural purposes in a region is restricted. The with-and-without principle is respected to show the effect of an adaptation possibility, like a lower crude protein level in feed concentrates.

Disposal costs

The price of organic manure is a crucial factor in the analysis, because mainly adjustments in mineral flows are considered. 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 insight in manure market interactions in the regions is rather limited, the level of disposal and purchase costs of animal manure is exogenously determined in the model and is assumed to be equal in all regions. Under stricter policy, changes in the level of the costs are exogenously determined as well. Disposal costs are accounted per kg of nitrogen, since policies assessed are restricting towards nitrogen. Disposal costs are assumed to be 1 ecu per kg of nitrogen in the scenarios *CAP-1988* and *CAP-1994*. Under stricter environmental policy more manure may be removed in regions with high concentration of manure production and the disposal costs per kg will increase. Costs of 2 ecu per kg of nitrogen disposed are assumed under strict policy in scenario *CAP-2000*. For a more detailed description of the model and the assumptions reference is made to Hellegers (1996).

Data

Data based on the 1990/91 sample of the Farm Accountancy Data Network (FADN) of the European Commission have been used. The sample includes 1,161 granivore farms, which in total represent about 60.7 thousand granivore farms in the EU. FADN contains only a restricted number of variables. Additional data like prices of in- and outputs have been obtained from other sources. Variable costs per crop for the year 1990/91 are obtained from the Sectoral Production and Income model for agriculture (SPEL/EC). Data needed to calculate mineral balances, like coefficients of nitrogen requirement and nitrogen uptake to grow crops, are based on figures used by Brouwer et al. (1995). Coefficients on the excretion of minerals from livestock are presented in section 4.3.

Appendix C Manure model of the Netherlands

LEI started their efforts in this field of research on manure in the early 1980s (Wijnands and Luesink, 1984). By that time the main objective of the work was to quantify the excess amount of manure produced in the country. Also, the model was used to assess the economic impact of national manure legislation.

Because of the increasing technical knowledge regarding transport and treatment of manure and by new ideas of the use of the models, it was required to update the models from early 1980s. This resulted into two new models with the names MESTOP and MESTTV (figure C.1) (Luesink and Van der Veen, 1989). MESTOP calculates the production of manure and the application room for manure at farm level. On farms where the production is higher than the application room excess manure is calculated and on farms where the application room is higher than the manure production application room for manure from other farms is calculated. MESTTV calculates with the results from MESTOP for 31 areas the application of excess manure where, in which amount and what kind; and the amount of excess manure that is processed and exported. By all those activities the total costs are calculated and minimized.

The emissions of ammonia became an important issue from a policy point of view around the end of the 1980s. By that time LEI also started their efforts to develop a model to assess emissions of ammonia (Oudendag and Wijnands, 1989). The models distinguish between the emissions from stables, storage, pasture (from grazing cattle) and application of manure. In 1991 LEI integrated the manure models and ammonia emission models.

The models are used extensively in the Netherlands. They are used among others to contribute to the evaluation of manure and ammonia policies of national government. Also, they are used to contribute to annual reports on the state-of-the environment as well as to long-term reconnaissances to the environment. Besides that the models are also used to serve regional governments in the country, either to assess mineral balances at regional level, or to assess excess amounts of manure produced at regional level.

In the framework of the present report emphasis has been given to the analyses which derive from the manure models. Therefore, we limit the description to these models only be described in the following.

MESTOP

The model calculates at farm level the manure production as a function of the amount of animals and the excretion pro animal. In scientific notation:

$$\overset{vmax}{\underset{v=1}{\varphi}} D(v) * E(v) * T(k) = P(k)$$

v = kind of animal
k = number of manure types

D = number of animals
E = excretion per animal
P = production at farm level
T = manure type
vmax = number of animal types

Besides the production the model calculates the application limit at farm level as a function of crop type and the size of the area used to grow this crop. In scientific notation:

$$\overset{lmax}{\underset{l=1}{\varphi}} A(l) * T(l) = PB(l)$$

A = area utilised to grow crop l (ha)
T = standard to apply nutrients from livestock manure at crop l (kg per hectare)
PB = maximum to be applied at crop l
lmax = number of crops grown

After that is calculated whether the farm is a deficit farm or an excess farm according to prevailing standards to apply animal manure. This is optimised under the restriction that the amount of excess manure (in volume) is minimal. In scientific notation:

$P(k) - PB(l) > 0$ manure excess = BO(j,k)j = holding j
< 0 application room = BP(j,l)

Under restriction $\overset{imax}{\underset{I=1}{\varphi}} BO(j,i)$ = minimized

BO = Excess manure
BP = Application room
imax= amount of farms pro area

The amount of excess manure and application room at farm level is counted to area level, which gives excess manure and application room at area level. In scientific notation:

$$\overset{imax}{\underset{I=1}{\varphi}} BO(i,k) = SURPLUS(g,k)$$ g = area

imax
φ BP(i,l) = DEFICIT(g,l)
I =1

MESTTV

This national model for transport and processing of animal manure excesses in The Netherlands analyses the complex problem in a consistent way. This model, using linear programming, gives an optimal solution of transport to deficit farms and of processing under the restriction of getting rid of all excesses. The utilization of manure is always within the allowed doses of the standards. This model can only be applied if the excesses (SURPLUS(g,k)) and deficits (DEFICIT(g,l)) have been calculated first. The transport, processing and export of MESTTV can be written with the following mathematical equations:

jmax31kmax lmax
(1) Minimize:TCOST =φCAP(j) * COST (j) - φφ φ VALUE (k,l) * USE(g,k,l)
j=1g=1 k=1 l=1
subject to:

31imax 31kmax lmax
(2) φφPROCES (g,i) * A1 (i,j) + φ φφUSE(g,k,l) * A2(k,l,j) +
g=1i=1g=1 k=1 l=1

31 31 kmax
φ φφ TRANS (k,g,gg) *A3 (k,j)=CAP(j)
g=1gg=1K=1
gg. g FOR j=1, jmax

imaxlmax 31
(3) φPROCES(g,i) * A4 (i,k) + φ USE(g,k,l) + φTRANS (k,g,gg) *A5 (k)* SURPLUS(k)
I=1l=1g=1
FOR g=1,31 k=1,kmaxSURPLUS(k) = BOmv

kmax
(4) φ USE(g,k,l) * A6(k,l) ˜ B1 * DEFICIT (g,l)
k=1
FOR g=31 l=1,lmaxDEFICIT(g,l) = BPms

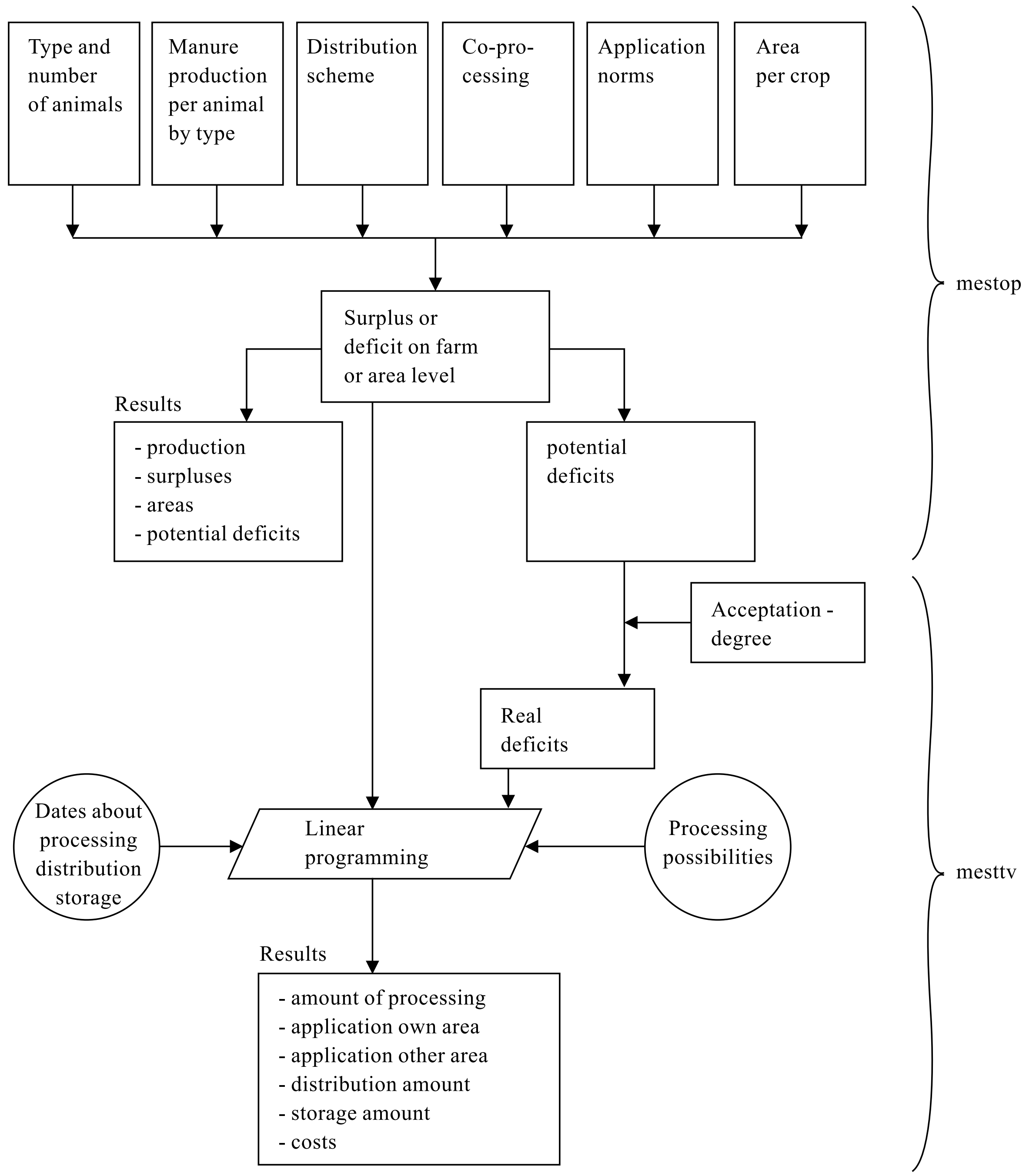


Figure C.1 Modules to calculate production and exess amounts of livestock manure

A1 - A6	Technical input/output coefficients
B1	Willingness to accept manure for a specific crop
CAP	The used amount of transport and or processing activities
COST	Cost per unit transported or processed
DEFICIT	Deficit of manure according to the standards
g or gg	Index areas
I	Index processing and export possibilities
j	Index investment activities
k	Index manure type
l	Index crops
SURPLUS	Excess of manure according to the standards
TCOST	Total cost of transport, processing and export of the manure excesses
TRANS	Transport of excess manure from one region to another
PROCES	Prcessing and export of manure
USE	The use of manure as fertilizer
VALUE	Value of manure

Table C.1 shows costs used in the model MESTTV to dispose excess amounts of manure (in ecu per tonne of manure).

The model distinguishes between 31 regions, between 9 and 17 types of manure (depending on the processing activities), and six categories of land use have been considered.

The objective of the model is to minimise total costs. In fact the value of the manure as fertilizer is subtracted from the total costs. But if an excess exists above crop requirements manure should not be considered as a fertilizer but as waste.

The second equation of the model identifies the investments required for processing, transport and export of the manure. The various options available are summarized in table C.1. Despite the fact that central processing of slurry requires a factory with a capacity of about 250,000 m³, the model is formulated as a linear programming problem and not as a mixed-integer programming problem. The excess amount of manure nearly always requires more investments than one unit.

The third equation implies that the total excess amounts of manure need to be disposed off, either by processing, export, application within the region or transported to another region. But if manure has been transported to another area, in that area the manure has to be utilized as fertilizer. From a theoretical point of view manure can be transported from one region to all others. This would imply the total transport options by type of manure would amount to 31 times 30. In reality there is no transport to regions with excess amounts of manure; neither there is transport out of region with a manure deficit. So it is only necessary to formulate transport possibilities from excess to deficit areas. Processing has as input a specific type of manure and as output other types of manure (e.g. manure with a higher percentage of dry matter, sludge, etcetera).

The fourth equation ensures that utilization of manure does not exceed deficits and the willingness of farmers to use manure from other farms. For example, if manure deficit in one region is assessed to be 1,000 kg of nitrogen, and the acceptance rate is 75%, a maximum of 750 kg of nitrogen may be utilised in that region. The results of the model are indications about the minimal costs, the manure transports, export and processing, the corresponding amounts and transport directions and the influences of future developments on the points mentioned before.

Table C.1 Costs used in the model MESTTV to dispose excess amounts of manure (in ecu per 1,000 kg of manure)

Process	Cost
Transport short distance	
- slurry	2.52
- dry manure	5.97
Transport long distance of slurry	
- fixed costs	5.42
- variable costs (per km)	0.027
Transport long distance of dry manure	
- fixed costs	9.66
- variable costs	0.058
Emission-low application of manure	
- slurry	3.38
- dry manure	5.31
Storage costs of manure (annual costs)	
- slurry a)	7.42/9.49
- dry manure	1.57
Export	38.65
Processing	
- manure from pigs and cattle	19.32
- manure from beef calves	5.31
- poultry (both dry and wet manure)	16.42

a) Differs among regions

Appendix D FADN farming types

Table D.1 Farming types according to the Farm Accountancy Data Network

9 Farming types		17 Principal farming types	
1	Cereal farms	Type 11	Specialist cereal
2	General cropping farms	Type 12	General field cropping
		Type 60	Mixed cropping
3	Horticultural holdings	Type 20	Specialist horticulture
4	Vineyards	Type 31	Specialist vineyards
5	Permanent crop holdings	Type 32	Specialist fruit and citrus fruit
		Type 33	Specialist olives
		Type 34	Various permanent crops combined
6	Dairy farms	Type 41	Specialist dairying
7	Drystock farms	Type 42	Specialist cattle-rearing and fattening
		Type 43	Cattle-dairying, rearing and fattening combined
		Type 44	Sheep, goats and other grazing livestock
8	Granivore farms	Type 50	Specialist granivores
9	Mixed farms	Type 71	Mixed livestock, mainly grazing livestock
		Type 72	Mixed livestock, mainly granivores
		Type 81	Field crops-grazing, livestock, combined
		Type 82	Various crops and livestock, combined

Source: CEC, 1989: 14.

Appendix E Scenarios used in the report

Agricultural policy:

- *CAP-1988* is based on the consideration of intervention prices and of prices of imported raw materials of the year 1990/91;
- *CAP-1994* is based on intervention prices, starting prices of imported raw materials, exchange rates and compound feed production for the year 1994/95 (the second year of the CAP reform);
- *CAP-2000* assumes an intervention price level of 1995/97 minus 10%. This scenario is based on a recent discussion paper on the future of the Common Agricultural Policy of the Ministry of Agriculture, Nature Management and Fisheries in the Netherlands (MLN.V, 1996).

Nutritional management

1. *Current nutritional management*. This scenario is based on least-cost formulation of diets using feedstuffs and feed supplements available to commercial companies. Its main objective is to provide feed for livestock which assures efficient performance in terms of feed:gain ratio and growth rate for meat animals. It ensures that the minimum nutritional requirements of animals are met at minimum cost which may be at the expense of the provision of excess nutrients, such as total dietary protein level. Hence, it ignores nitrogen output.
2. *Controlled nutritional management*. This scenario assumes that the reduction of nitrogen output is now also taken into account in feed formulation. It ensures that nitrogen output is reduced using commercially-available feedstuffs and feed supplements. Feed prices may differ from *current nutritional management* as dietary protein level is likely to be reduced to a technically proven limit which does not compromise animal performance.
3. *Potential nutritional management*. This scenario formulates feed according to scientifically established nutrient requirements of the animal. As a consequence, dietary protein levels will be very low and nitrogen waste minimized. Tools to realise this option are available (including supplementary amino acids such as histidine, isoleucine and valine), but not yet on large commercial scale. Hence, compared with the other scenarios, the feed price today will be high. Increased commercial demand for such tools may make them economically in the future.

Environmental legislation:

- *Application standard*. The application of nitrogen from livestock manure should not exceed 170 kg of nitrogen per ha. This standard is one of the main elements of the Nitrates Directive, which should be met at farm level in zones vulnerable to the leaching of nitrates by the year 2003.

- *Mineral balance*. This scenario is targeted on nutrient surpluses, rather than on the application of nitrogen from livestock manure. It is based on the mineral declaration system (mineralenaangiftesysteem, MINAS) which are required in the Netherlands as of 1998 by all intensive livestock producers with animal density which exceeds 2.5 livestock units per ha.

Appendix F Glossary of terms used in the report

BLEU	Belgium and Luxembourg Economic Union
BOD	Biochemical Oxygen Demand
CAP	Common Agricultural Policy
CCM	Cereal and Compound Feed Market Model
ECU	European Currency Unit
EIA	Proposal to amend Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment
EU	European Union
FADN	Farm Accountancy Data Network of the European Commission
FEFAC	
FEM	Farm European Mineral Model
Final production	Sum of intermediate consumption and gross value added at market prices
FSS	Farm Structure Survey of Eurostat
IPPC	Position adopted by the Council of Ministers with a view to adopt a Council Directive concerning Integrated Pollution Prevention and Control
LEI	Agricultural Economics Research Institute
LU	Livestock Unit; a unit representing the nutrient (energy) value of feed
Mineral book keeping	A system of mineral book keeping is required to calculate the mineral balance
Mineral balance	Tool to provide insight into flows of nutrients across agriculture. Defined as the difference between input and output flows
Nitrates Directive	Council Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources (Directive 91/676/EEC)
Nitrogen surplus	Difference between input and output flows of nitrogen