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MANURE POLICY AND MINAS: REGULATING NITROGEN AND PHOSPHORUS SURPLUSES IN AGRICULTURE OF THE NETHERLANDS

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FOREWORD

This report has been prepared as part of the work programme of the Joint Meetings of Tax and Environment Experts under OECD's Fiscal Affairs Committee and Environment Policy Committee. It was prepared by Oene Oenema and Paul B.M. Berentsen of Wageningen University and Research Center.[1] Similar case studies on how the political obstacles to the introduction of economic instruments for environmental policy with potentially negative impacts on sectoral competitiveness have been overcome have been prepared concerning the Heavy Goods Vehicle fee in Switzerland and Climate Change Levy in United Kingdom. A similar study on the taxation of fuels used in domestic commercial aviation in Norway will be prepared in 2005.

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EXECUTIVE SUMMARY

Environmental policies in agriculture have economic consequences.

Agriculture in Europe and especially in the Netherlands is increasingly affected by environmental policies and measures. The effectiveness of these environmental policies and measures in agriculture is still limited, while the economic cost associated with the implementation of environmental policy can be high. More than 10 years after approval of the EU Nitrates Directive (91/676/EEC), there is a delay in the implementation and enforcement in many member states, which reflects in part the large complications that arise from this Directive for intensive livestock farming. It also reflects that environmental policies in agriculture have economic consequences.

The nitrogen and phosphorous accounting system MINAS marks a shift towards use of economic incentives.

This report deals with the manure policy in The Netherlands, with a special focus on the effectiveness and efficiency of the economic instrument MINAS. The manure policy of the Netherlands is a complex policy that addresses a stubborn and complicated problem. The manure policy has a history of almost 20 years of changes, successes and failures. The nitrogen (N) and phosphorous (P) accounting system MINAS implemented at farm level in 1998 has been the core instrument of the third phase of the manure policy, and marks a shift in the manure policy from regulations and measure-oriented policies in the first and second phases between 1984 and 1998 towards target-oriented policies with stimulations via economic incentives. MINAS was intended to be also the main instruments to implement the EU Nitrates Directive.

The effectiveness of MINAS has varied between farm types.

Monitoring results indicate that the N and P accounting system MINAS is an effective policy for decreasing total nutrient losses from especially dairy farms. Potentially, it could be also an effective instrument for arable farms, but there is no clear evidence yet. MINAS has turned out to be not effective and efficient for pig and poultry farmers.

Additional instruments have been implemented to support MINAS.

Though MINAS is an integrated and flexible instrument and in principle applicable to all farms, the differences between sectors are so large and the complexity of the manure problem is so big that the results so far indicate that a single instrument like MINAS cannot solve the manure problem at once. As a consequence, additional instruments have been implemented to support MINAS, but not all these additional instruments appeared to be effective and supportive. There have been also quite some changes in MINAS and the additional manure policy instruments between 1998 and 2004. which often led to confusion and disbelief among farmers (and policy makers), which further complicated effectiveness and efficiency of these instruments.

Administrative costs have been high.

The economic costs for enforcement and monitoring of MINAS and other instruments have been increasing greatly over the last few years. The high cost for administration is in part caused by exploitation of loopholes, fraud, juridical procedures, and by the many changes that have been made in the MINAS system and in the additional policy instruments. Due to these many changes, there has been insufficient time for proper implementation and fine-tuning of MINAS in practice. As such, MINAS has not received the credits that it would deserve as an instrument to decrease nutrient losses from agriculture

MINAS will be replaced by application limits for animal manure and fertilizers.

A judgement of the European Court, the increasing administrative burden, increasing fraud, and the near absence of environmental benefits in the pig and poultry sectors (where manure surpluses are largest) have led to a very rapid erosion of MINAS. By the end of 2005, MINAS will be replaced by a (complex) system of application limits for animal manure and fertilizers, in compliance with the Nitrates Directive. It remains to be seen whether such a system is equally effective and efficient for dairy farms, arable farms and pig and poultry farms.

For more information about the **MANURE POLICY AND MINAS: REGULATING NITROGEN AND PHOSPHORUS SURPLUSES IN AGRICULTURE OF THE NETHERLANDS**, contact: Nils Axel Braathen, National Policies Division**,** Environment Directorate, OECD. Email – Nils-Axel.Braathen@oecd.org; Fax : +33 1 44 30 63 99.

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MANURE POLICY AND MINAS: REGULATING NITROGEN AND PHOSPHORUS SURPLUSES IN AGRICULTURE OF THE NETHERLANDS

1. Introduction

1. Agriculture exerts various effects on the wider environment. Until recently, these effects were considered to be beneficial, or were simply ignored. This general perception changed from the 1970s onwards, when the effects became more pregnant, following the large-scale intensification of agricultural production in developed countries, and were better understood through the advancement of science. Current perception is that especially intensive agriculture has various negative effects on the environment. Forecasts suggest that further intensification of global agricultural production using current technologies may even have dramatic effects on the wider environment during the next decades (e.g. Tilman et al., 2001; 2002). Main problems arise from excess nitrogen (N) and phosphorus (P) originating from animal manure and fertilizers, which contribute to eutrophication of natural areas, to contamination of groundwater, to acidification of soils and lakes and to the emission of the greenhouse gases (N_2O) into the atmosphere (e.g. Vitousek et al., 1997; Tilman et al., 2001; Robertson et al., 2000).

2. The first environmental policies and measures regulating the use of animal manure and fertilizers date from the 1980s. These governmental policies and measures were most pronounced in the European Union (EU), in particular in The Netherlands (e.g., De Walle and Sevenster, 1998; De Clercq et al., 2001). Nowadays, all farmers in EU are confronted with an increasing number of regulations and incentives, to transform current farming practices into more environmental friendly farming practices.

3. This paper discusses the manure policy in the Netherlands with emphasis on the N and P accounting system MINAS. MINAS was introduced by the Netherlands' government in 1998, to step-wise decrease the N and P surpluses at farm level in 5 to 10 years to environmental acceptable levels (e.g. Henkens and Van Keulen, 2001). Individual farms that exceed certain levy-free surpluses for N and P (expressed in kg per ha per year) are charged with a financial levy, so as to encourage farmers to decrease the N and P surpluses. Whilst the use of nutrient balances in agricultural research has a history of at least one century, using nutrient balances with levies on surpluses as an instrument to ecologically transform agriculture had no precedent.

4. Though the manure policy greatly affects agriculture in the Netherlands, it would be naïve to ascribe all changes in agriculture to the manure policy and all effects of the manure policy to MINAS. Agriculture in the Netherlands is heavily influenced by changes in the (export) markets for agricultural products in general and by (the reforms of) the common agricultural policy (CAP) of the EU in particular. This complicates assessment of the effects of the manure policy in general and those of MINAS in particular

5. The first two chapters of this paper provide background information about the development of agricultural and about the development of the so-called manure policy in the Netherlands, respectively. Chapter 4 discusses the environmental and economic effects of the manure policy, based primarily on two recent fact-finding studies (RIVM, 2002; 2004). Finally, Chapter 5 contains the discussion and summarizes the major conclusions.

2. Developments in agricultural in the Netherlands

2.1 Site description

6. The Netherlands (NL) is situated along the North Sea in the western deltas of the rivers Rhine, Meuse and Scheldt and the northern delta of the Ems. The surface area of the Netherlands (34,000 m^2) is much smaller than that of the river basins of the Rhine (185,000 km^2), Meuse (36,000 m^2), Scheldt (22,000 km^2) and Ems (85,000 km^2). All four river basins are densely populated (100-450 inhabitants per km^2), industrialized and have intensively managed agriculture. As a consequence, N and P discharges into the North Sea by the rivers Rhine (255 million kg N and 4 million kg P), Meuse (40 million kg N and 2 million kg P), Scheldt (39 N and 3 million kg P) and Ems (about 80 million kg N and 3 million kg P) are relatively large and together with the discharges from NL itself, greatly affect surface water quality in the deltas and North Sea.

7. About 60% of the total surface area of NL is agricultural land, 15 % surface waters, 15 % urban and infra-structural area and 10% natural area (forests, heath land, wetlands). Surface waters (lakes, canals, ditches and rivers) are diffusely distributed predominantly in the northern and western half of the country, which is below mean sea level. Natural areas (forests, pools, heath land) are found predominantly in the central, southern and eastern half of the country, which is above sea level. The northern and western half is characterized by clay and peat soils, with shallow groundwater levels (0.2-1.0 m below surface level). The central, southern and eastern half is characterized by sand and löss soils, with shallow to relatively deep groundwater level (1-10 m below surface level).

8. The northern and western clay soils are predominantly used for arable land (potatoes, sugar beet, cereals, flowers, vegetables) and dairy farming (using mainly grass as forage). Peat soils are predominantly used for dairy farming and some for ornamental culture (tree nurseries). The central, southern and eastern sand and löss soils are predominantly used for dairy farming (with grass and silage maize as forage crops). Also intensive animal production (pigs and poultry farms) is found in these areas.

9. Current agriculture in NL is highly intensive and productive. In monetary terms, it ranks among the first in the world as net exporter of agricultural products. Yields of potatoes, sugar beet, vegetables, cereals and flowers in NL agriculture are among the highest in the world. Livestock density, animal manure production, and fertilizer use are among the highest of all member states in the EU (Table 1; Figure 1). The average total amounts of N (corrected for ammonia losses) applied to agricultural land in the EU in 1997 via animal manure and fertilizers ranged from about 85 kg per ha in Austria to about 360 kg per ha in NL. Similarly, the average total amounts of P applied to agricultural land in 1997 via animal manure and fertilizers ranged from 31 kg per ha in Austria to 120 kg per ha in NL. The average N surplus in the EU-15 was 57 kg per ha in 1997, ranging from 30 kg per ha in Greece to 249 kg per ha in NL. There is strong correlation between livestock density, N fertilizer input and N surplus per ha; countries with the highest livestock density also have the highest N fertilizer input and highest N surplus on the soil surface balance (Figure 1). Correlation coefficients for linear relationships between fertilizer N, manure N and N surplus in the EU-15 range between 0.8 and 0.9.

10. Key factors for the intensification of agricultural production in NL were (Bieleman, 2000): (i) The geographical position of NL, between densely populated areas; (ii) The governmental policy, strongly supporting a competitive agriculture; (iii) Intricate relationships between agricultural research, education and extension; (iv) A strong agribusiness, with an innovative supplying and processing industry; (v) Abundance of cheap natural gas, supporting fertilizer manufacture and greenhouse horticulture and floriculture; and (vi) The foundation of the EU which greatly enlarged the markets and supported the intensification of agricultural production. A brief historic overview of the agricultural developments during

the last one and a half century further may help to understand the background of the intensification of agriculture in NL further (after Oenema et al. in preparation).

2.2 From traditional to modern farming (1850-1950)

11. The industrial revolution, developments in technology and markets, and governmental interference contributed to fundamental changes in agriculture and in the relationship between agriculture, nature and society of industrializing countries in the second half of the 19th century and first half of the 20th century. Availability of energy from fossil fuel, and scientific breakthroughs in technology, transport, plant nutrition and crop and animal husbandry increased agricultural production and contributed to enlarging of markets (e.g. Slicher van Bath, 1960; Van Zanden, 1985; Bieleman, 1992; Smil, 1994). These breakthroughs among others led to a flood of arable products from America and Eastern Europe on Western European markets. This dropped the prices for agricultural products and led to the agricultural crisis of the 1880's (e.g. Dovring, 1965). In response to these developments, the Dutch government for the first time started to systematically stimulate agricultural research and education, and introduced a market and price policy that focused on improving the structure of and productivity in agriculture and on enlarging the export of agricultural products. The government also stimulated reclamation of the remaining natural areas and common grounds, mainly heath land on poor soils, drainage of swamps, and the reclamation of new land from sea and lakes. The treaty on land exchange from 1924 facilitated the change from a patchy and highly diversified landscape into a more uniform landscape with larger fields, so as to farm more economically. All theses governmental incentives increased productivity in agriculture, but it also led to the impoverishment of the rural landscape. A small group of people who considered these changes as highly negative to nature and humanity founded the private nature conservation society "Natuurmonumenten" in 1905. This is now the largest foundation and the largest landowner of The Netherlands.

12. In the beginning of the 20th century, farmers started to organize themselves via interest groups and co-operatives, for example for processing milk into butter and cheese, for breeding improved varieties of potatoes, cereals and sugar beet, and for breeding improved dairy cattle. This improved the yield, quality and marketing of the products.

13. Between 1850 and 1950, total population in The Netherlands increased exponentially from 3.0 to 10 million and population density increased from 100 to 300 inhabitants per km^2. The percentage of the labour force employed by agriculture decreased from 50% in 1800 to 44% in 1850 to 20% in 1950. However, the total number of people working in agriculture steadily rose from 0.4 million in 1800 to 0.5 million in 1850 and peaked at 0.75 million in 1947. The total number of farms steadily increased from about 130,000 in 1800 to 160,000 in 1880 and 235,000 in 1930. Especially the number of small farms increased up to 1930, but decreased thereafter. The increase in number of farms was made possible by the increase of agricultural land through reclamation of natural and common areas (see Table 2), and through splitting the farm in two or more farms. The area of cereals and cash crops (flax, rapeseed and madder) remained more or less stable, but the area of potatoes, sugar beet and grassland increased. Productivity per unit of land increased as a result of improved management, a change in crops and varieties, and the increased use of fertilizers (e.g. Table 2). Yields of crops doubled between 1850 and 1950, but the strongest increase occurred during the second half of this period, coinciding with the increased use of fertilizers (Table 2). However, most farmers did not benefit from the increased productivity, and remained poor.

2.3 From modern to highly intensive farming (1950-1985)

14. With two World Wars, a serious economic crisis and regular food shortages in mind, there were strong feelings and incentives in European countries after World War II to stimulate the economy and to

boost industrial and agricultural productivity. The establishment of the European Economic Community (EEC; later European Union, EU) in 1957 ensued from these general feelings. At that time, Western Europe was a net importer of food, and understandably, the Common Agricultural Policy (CAP) of the EU was strongly focused on stimulating agricultural production and stabilizing markets. Within a couple of decades, CAP indeed changed the EU from a net importer to a net exporter of food. Initially, these food surpluses were regarded as pleasant, but because of the price support, the surpluses became a financial burden.

15. The Netherlands is one of the six initial members of the EEC, and its agriculture has benefited from the CAP. The focus on food security and the establishment of common markets within the EU contributed strongly to intensification, specialization and increase in scale of agricultural production. Price support of cereals and butter provided farmers financial security and stimulated production. Subsidies provided incentives to farmers for land reclamation and land exchange, for building new stables and for buying machinery, so as to increase the competitiveness of the agricultural sector. Technological innovations contributed to increases in production. The demand for labourers by industry and services, and the pressure to work hard for relatively low incomes in agriculture stimulated the exodus of labour force from agriculture, firstly of contracted labourers, then assisting family and finally farmers themselves.

16. Changes in agriculture were most intense in the period 1960-1985 (Table 3). In this period, the production of crop and especially animal products increased strongly. The increasing agricultural production was only for a small part for inland consumption. By far the major part of the agricultural production was exported. The export market appeared to be economically attractive, especially for animal products, flowers and some vegetables. The ample availability of natural gas following the discovery in the province Groningen in the 1950's, and its supply to greenhouse farmers at reduced price boosted greenhouse horticulture and floriculture. The surface area of greenhouse s increased from 3,000 ha unheated and non-illuminated greenhouse s in 1950 to 10,000 ha heated and illuminated greenhouse s in 1980 (and to 16,000 ha in 2000). Because of this increase in production, and the high-market value of vegetables and flowers (mainly for export), the greenhouse sector became an important economic sector. The other side of the coin was that the greenhouse sector became a highly energy-intensive sector, consuming more than 80% of the fossil energy used in agriculture in The Netherlands.

17. The large increase in animal production was made possible through the fertilizer induced boost in animal feed production (mainly grass and silage maize) and through the large-scale import of cheap animal feed stuff from outside the EU, which was not prohibited by EU-tariffs. These changes led in part to uncoupling of crop production and animal production; animal production was not limited anymore by the local agricultural surface area and its crop production. Increases of scale, intensification and specialization were greatly facilitated by suppliers of animal feed, fertilizers, machinery and finance, and by the processing industry. They have greatly contributed to the economic strength of the agro-complex. The economic added value by of agribusiness has become three to four times as large as that of the primary producers.

18. However, the rapid increase of productivity and increased production volume surpassed the increasing demand for food by the growing population from the seventies onwards. This led to food surpluses and, consequently to decreasing prices for agricultural products that were not supported by the EU. The pleasure of food surpluses from food security point of view transformed into a financial burden because of vast surpluses of price-supported cereals and milk. This threatened the economic position of the EU. Further, the increasing animal density produced increasing amounts of animal manure, and the area of land needed for the recycling of the nutrients contained in the animal manure in an environmentally benign manner became insufficient. This led to a surplus of animal manure which threatened the environment. As a result, farmers were in danger to become ruined by their own success. The burden of both type of surpluses changed the position of the agricultural community in the society. The cost to the EU of getting

rid of the surpluses of butter and cereals increased dramatically. Surpluses of animal manure were associated with phosphorus saturated soils, forest dieback due to ammonia volatilization, nitrate contaminated groundwater, and eutrophication of lakes and seas. These developments fuelled the establishment of green action groups, which put increasing pressure on the government to take actions. Farmers were blamed for both pocketing subsidies and being environmental criminals (Krielaars, 1965; Bloemendaal, 1995; Lowe and Ward, 1997).

2.4 From highly intensive farming to regulated farming (1985 to present)

19. Increased awareness of environmental impacts of intensification of agricultural production, and of the relationships between the Common Agricultural Policy in the EU and surpluses of milk and cereals, drastically changed the agricultural policies of EU and The Netherlands from the mid 1980's onwards (e.g. Brouwer and Lowe, 1998). Marketable quotas of milk, sugar and starch potatoes, and marketable production rights for pigs and poultry based on the amounts of phosphate excreted via animal manure were implemented from 1984 onwards and greatly decreased the degrees of freedom for agricultural entrepreneurs (see also chapter 3). Decreases in the price support of cereals and milk, implementation of set-aside subsidies, and policies and measures on the application of animal manure and of chemical crop protection further restricted farming possibilities. Agreements between government and greenhouse farmers focused on a step-wise increase in energy use efficiency by up to 80% in the greenhouse sector. All these governmental policies were meant to set limits to emissions of ammonia, nitrogen, phosphorus, odors, heavy metals and chemicals into the wider environment. Codes of good agricultural practices and best management practices were developed and farmers were trained and encouraged to implement these in practice.

20. Effects of milk quota and policies on animal manure and fertilizers are noticeable through decreases in animal number and in the use of N and P fertilizers (Table 3). The number of dairy cows decreased from 1985 onwards. The number of pigs started to decrease from the end of the 1990's, because of the outbreak of classical swine fever and the buy-out of pig production rights by the government. The number of poultry continued to increase until poultry production rights were established in 2002, followed by a buy-out of poultry production rights by the government (see also chapter 3.6). The implementation (from 1998 onwards) of the N and P accounting system MINAS with levies on environmentally unacceptable high surpluses at farm level, forced farmers to lower the input of N and P via fertilizers, animal feed or animal manure, and to increase the N and P use efficiency. As a result, N and P surpluses in agriculture decreased.

21. In 1999, there were some 100,000 farm holdings left (Table 4). The dairy sector still used more than 50% of the agricultural land. Farms with the largest surface area were found in arable farming, while the smallest area per farm was in greenhouse horticulture and floriculture. In the 1990's the number of farms decreased at a rate of about 3% per year (CBS/LEI, 2000), while the total surface area of agricultural land decreased by 0.3 to 0.5% per year. This indicates that the average size of farms increased steadily.

3. Developments in manure policy in the Netherlands

3.1 Too much of a good thing

22. First signals that the rapid intensification of animal agriculture was not environmentally sustainable date from the end of the 1960s. However, the cause - effect relationships were initially not clear. From the beginning of the Industrial Revolution, the country-side was seen as natural and healthy compared to industrialized urban areas, and agriculture was seen as the country-side. This view changed slowly upon the appearance of an increasing number of reports about nitrate leaching to groundwater, copper accumulation in pig slurry treated soils, phosphorus saturated soils, surface water eutrophication by

N and P from agriculture, and soil acidification and suggested forest dieback due to ammonia from animal manure. These reports formed the basis for the foundation of green action groups, which put increasing pressure on policy makers to change policy from promoting agricultural productivity to environmental protection and nature conservation.

23. Element balances have played a key role in understanding the effect of intensification and specialization of agricultural production on nutrient use efficiency and nutrient losses (e.g., Frissel and Kolenbrander, 1977). Animal agriculture in NL heavily relies on imported animal feed, and although a large fraction of the animal products is exported again, the animal manure containing most of the nutrients of the animal feed and feed additives, was applied to the small acreage of land of the animal farmers. The manure surplus appeared to be a nutrient surplus, a surplus of especially nitrogen (N), phosphorus (P), potassium (K), copper (Cu) and zinc (Zn). These surpluses were perceived differently by the different actors involved. For some, it took many years to accept that there could be too much of a 'good thing'. Throughout history, animal manure had always been scarce, and suddenly there was a surplus.

3.2 Three phases in the manure policy

24. The general aim of the manure policy in the Netherlands is to decrease the losses of N and P from agriculture to the environment (atmosphere, groundwater and surface waters) to environmentally acceptable levels. An important constraint is the socio-economic impact; the manure policy should not deteriorate the socio-economic strength of the agricultural sectors (too much). Further, the manure policy must be effective and efficient. In practice, the instruments of the manure policy have to realize three common aims at the same time:

1. On intensive livestock farming systems, the surplus amount of animal manure has to be transferred to farms that can accommodate this manure or it has to be (processed and) exported;
2. On farms that accept animal manure from other farms, N and P losses may not increase above environmentally acceptable losses, even when it is financially attractive to buy animal manure from other farms;
3. On all farms, the N and P losses have to be decreased to environmentally acceptable levels, through a drastic improvement of N and P use efficiency.

25. This is common knowledge now, but it took quite some time to realize the implications of these three common aims in terms of designing effective policy instruments. Initially, the nature and complexity of the manure problem was not understood well, there was certainly no consensus about the severity of the problem and there was also no consensus about the instruments needed to solve the problem. Moreover, there was and is still a lack of understanding of the relationships between "type of policy instrument - behaviour of farmers - agronomical and environmental effects". The response of farmers to the implementation of manure policy and measures appeared to be more varied and complex than initially expected. In retrospect, there has been quite some trial and error in the manure police of Netherlands.

26. The first governmental policies and measures regulating animal manure date from 1984. Roughly three phases can be distinguished in the so-called manure policy (Henkens and Van Keulen, 2001), namely (i) stop growing animal production (1984 to 1990), (ii) step-wise decrease of the manure burden (1990 to 1998), and (iii) balancing inputs to outputs as regards N and P (1998 to present). The step-wise implementation of measures in the subsequent phases allowed farmers to adapt gradually to increasingly tighter environmental requirements and to adopt environmentally friendly production methods. Initially, there was a strong belief that the manure burden could be solved by technological innovations. This belief was partly based on the conviction that structural measures, i.e. a decrease in the number of livestock, were politically not realistic.

27. The first phase of the manure policy banned further growth of pig and poultry sectors. These sectors grew almost exponentially in the sixties, seventies and first half of the eighties (Table 3), and initially the manure surplus was strongly associated with pig and poultry production. The ban on further growth of pig and poultry sectors coincided with the introduction of milk quotas in member states of the EU, to limit the growth of the surpluses of dairy products (notably butter) and thereby to limit the intervention costs for the EU. The implementation of the milk quota banned the growth of the dairy sector. As the milk quota decreased in subsequent years while the milk production per cow continued to increase, the number of dairy cows started to decrease for the first time. During the first phase limits were also implemented for the application of animal manure to agricultural land, based on the amount of P in the manure. Initially, these limits were much higher for maize land (350 kg P_2O_5 per ha per year) than for grassland (250 kg P_2O_5 per ha per year) and arable land (125 kg P_2O_5 per ha per year). These initial limits reflected where the pressure of the manure burden was highest. The first phase of the manure policy is further characterized by the belief that the manure surplus can be solved by technological innovations. Various pilot plants were set-up to explore the possibilities for manure processing and initiatives were made for marketing processed manure abroad. Most of these initiatives failed, except for those concerning drying and pelletizing poultry manure for export to surrounding countries.

28. The second phase started roughly in 1990/1991, and can be characterized by (i) lowering of the application limits for animal manure, (ii) restrictions on the timing of manure application and the resulting requirement to take care of sufficient storage capacity for animal manure, (iii) implementation of various measures to decrease NH_3 emissions, and (iv) further facilitation of manure distribution and manure processing. The application limits for animal manure were lowered step-wise, e.g. for maize land from 350 kg in 1987 to 200 kg in 1991 to 100 kg in 1998 and to 80 kg P_2O_5 per ha per year in 2002. Because of the rather fixed ratios between N and P in animal manure, the amounts of N in animal manure decreased also step-wise. Restrictions on the application of animal manure in autumn and winter forced farmers to build facilities for storing animal manure for up to 6 months. The policy decision to decrease NH_3 emissions by 65-70% in 2000 relative to 1980 led to various regulations, including the requirement to cover all manure storage facilities, to apply animal manure to land via injection into the soil or via immediate incorporation into the soil following surface spreading, and to build low-emission animal housing systems when old ones had to be replaced. An agreement was made with the suppliers of animal feed to lower the phosphorus and protein contents of the animal feed and thereby the P and N excretion of the animals and the emission of NH_3 from manure. Finally, the transport of animal manure from areas with a large surplus to areas with a potential demand for manure was subsidized and facilitated, to decrease the environmental burden in the areas with intensive livestock production.

29. The various regulations implemented in the second phase were partly successful. Manure distribution from the southern and eastern half of the country to the western and northern parts of the country was successful. The step-wise lowering of the application standards meant that more and more manure had to be transported while arable farmers got less and less room for accepting animal manure. This led to increasing pressure on the so-called “manure market” and increasing cost for manure disposal. Ammonia emissions decreased greatly, but the policy targets for NH_3 emissions have not been achieved yet. The counter effect of implementing low-emissions techniques was that more N remained in the manure and subsequently applied to land, while fertilizer N dressings did not decrease in proportion, initially. As a result, N supply to the land remained high and the N content of the grass too. As N excretion by cattle is related to N content of the ration, and NH_3 volatilization to N excretion, animal manure of cattle remained a large source of NH_3.

30. The third phase started with the implementation of the nutrient accounting system MINAS at farm level in 1998, following consultation between the agricultural sectors and the Government. This phase was meant to solve the remaining nutrient surpluses at once. This phase also marks a change in understanding and policy. Technological innovations were no longer seen as the main solution for the

manure burden. The insight grew that a drastic improvement of nutrient management would be needed to decrease N and P losses at farm level to environmentally acceptable levels. The third phase also marks a change from a policy that was largely based on regulations to a policy that is based on economic stimulations (e.g., Baumol and Oates, 1988). MINAS was seen as a flexible instrument that would be able to address the large differences between farms in environmental performance.

3.3 The N and P accounting system MINAS

31. The nitrogen (N) and phosphorous (P) accounting system MINAS was implemented at farm level in 1998 on livestock farms with more than 2.5 livestock units per ha, and in 2001 on all other farms. MINAS involves registration of all N and P inputs and output at farm level, using a farm-gate balance sheet approach (See Box 1 and Table 5). Inputs of N and P via fertilizers, animal feed, animal manure, compost and other sources, as well as the N and P output (export at farm level) in harvested products, including any animal manure have to be recorded accurately, using official documents for sales and purchases from accredited firms only.

32. The difference between total N and P inputs and outputs should not exceed certain ‘acceptable’ (levy-free) surpluses for N and P. When N and/or P inputs exceed the N and/or P outputs plus the levy-free surpluses for N and P, farmers pay a levy which is proportional to the exceedance to the levy-free N and/or P surpluses. Levies provide the incentive to both lower the import of N and P in fertilizers, animal feed and/or animal manure, and to increase the export from the farm of harvested products and animal manure. Levy-free surpluses are differentiated according to soil type and land-use, and have been lowered step-wise between 1998 and 2003. The levy-free surpluses are a compromise between agronomic and environmental objectives and interests, as they are the result of political debate in the Parliament.

33. Surpluses at farm level that exceed levy-free surpluses are charged. In 1998, levies were 0.68 euro per kg per ha for N and 2.6 - 10.4 euro per kg per ha for P. In 2002, levies were raised to 2.53 - 5.07 euro per kg per ha for N and to 20.60 euro per kg per ha for P, which is about 5 to 10 times the price of fertilizer N and 50 times the price of fertilizer P, respectively. Levies were increased in 2002 to make them prohibitive, in response to queries by the European Committee about the effectiveness of the initial levies.

34. The basic reasons for implementing a farm-gate balance approach for nutrient accounting (MINAS) was the need to regulate N and P from both fertilizers and animal manure. Further, there was need for an instrument that provides an incentive for good nutrient management at farm level. MINAS was seen as both a management instrument for farmers to improve nutrient management at farm level and as a regulatory instrument for the government to regulate N and P losses from agriculture to the wider environment, i.e. to groundwater, surface waters and atmosphere.

35. Levy-free surpluses have step-wise been decreased between 1998 and 2003, on the basis of (political) compromises between what is environmentally acceptable and agronomically feasible. Tables 6 and 7 provide an overview of the levy-free surpluses, according to the Manure Act. Levy-free surpluses for N on grassland decreased from 300 kg per ha per ha in 1998 to 140 and 180 kg per ha per year in 2003. Levy free surpluses are lower for grassland on nitrate leaching sensitive dry sandy soil (140 kg) than on other soils. Similarly, levy-free surpluses for N on arable land decreased from 175 kg per ha in 1998 to 60 to 100 kg per ha per year in 2003. Levy-free surpluses for P decreased from 17.5 kg per ha per ha in 1998 to 8.7 kg per ha per year in 2003. There is no difference between soil types in levy-free P surpluses, whilst differences between land use are small (Table 7).

36. The size of the levy-free surpluses and the size of the levies define the room to act by farmers. When levy-free surpluses are low, farmers have small room to act. They can not utilize all potentials of the

farm or have to pay the cost for disposal of excess manure to elsewhere. They are forced to decrease the import of N and or P via fertilizers, animal feed or animal manure and compost, and to increase the efficiency of utilization of the smaller amounts of N and P that can be imported, in order to maintain the yields at similar level. They are challenged to implement cost-effective measures to decrease N and P surpluses. In principle, farmers have the choice of decreasing the surpluses to the level of the levy-free-surpluses and pay no levy, or to decrease the surpluses less and pay a levy in proportion to the exceedance of the levy-free surpluses. In practice however, the levies are meant to be prohibitive, and taking measures is more economical than paying levies.

37. The size of the levy-free surpluses and the size of the levies define also the losses of N and P to the wider environment. MINAS presumes a relationship between the size of the levy-free surpluses and the size of N and P losses to the wider environment. In the long-term, in a steady-state situation, N and P surpluses according to MINAS are indeed a proper indicator for N and P losses to the environment. In the short-term, this is not the case, though there are differences between N and P (Box 2). The lack of a direct relationship between N and P surpluses in agriculture and N and P losses from agriculture is often confusing and an item for debate in practice (e.g., Schröder et al., 2003). Farmers often find it frustrating that their efforts to decrease N and P surpluses have so little direct impact on environmental quality. The lack of a direct relationship between N and P surpluses in agriculture and N and P losses from agriculture is also basis for skepticism about the environmental effectiveness of MINAS and at the same time the main argument in the political debate for decreasing levy-free surpluses less than initially planned.

38. There have been a large number (about 40) of alterations and changes in MINAS since its implementation in practice in 1998. These changes include changes in the size of the levy-free surpluses (Tables 6 and 7) and the size of the levies, but also in default values and various correction factors (e.g. RIVM, 2004; Schröder et al., 2003). These changes have been made in response to increased insights over time, complaints by farmers and political lobbying. Not all of these changes have made MINAS more effective and transparent; in some sense they have also led to confusion by farmers. A strongly debated change was the exclusion of fertilizer P as an input on the MINAS balance, in response to (political) pressure from arable farmers to block implementation of MINAS in arable farming in 2001, unless P fertilizer was excluded from the accounting.

39. Various documents are available to help farmers to complete the MINAS balance, but the diversity among farming systems and the many corrections make accounting still a complicated effort. In practice, specialized accountancy agencies do the job. Registration of the N and P inputs and outputs in MINAS can be done either via the standard refined accounting or via the fixed accounting using default values. In the standard refined accounting, all inputs via animal manure, compost and sludge, fertilizers, animal feed and animals, and all outputs via animal products including sold animals, animal manure, and sold crops at farm level have to be quantified using certified procedures. Corrections in the standard refined accounting include those for gaseous N losses from animal manure during storage. The fixed accounting focuses on animal manure, on the manure produced on the farm, and possibly on the manure imported from other farms. In general, it is easier to complete the fixed accounting documents than the standard refined accounting documents, but the room to act for farmers is also much smaller. Therefore, fixed accounting is mainly applied by animal farms with a low livestock density. In practice only about 10% of the farmers apply for the fixed accounting (RIVM, 2004).

40. The question remains why MINAS was implemented at *farm level* to regulate surpluses of N and P? Indeed, various alternatives have been discussed as well like taxes on N and P in fertilizers and on N and P in imported animal feed (concentrates). Also a general creaming off or buying out of animal production rights to lower the livestock density have been discussed. However, these alternatives were either deemed politically not acceptable or practically impossible. Taxes on fertilizers and concentrates negatively influence the competitiveness of the animal farmers relative to their colleagues in the member

states of the EU. Moreover, it is almost impossible to control the import of fertilizers and animal feed from the neighbouring countries.

Box 1. Objectives and approaches of nutrient balances (after Oenema et al., 2003)

Nutrient balances summarize nutrient inputs in and outputs from a defined system over a defined period of time. Balances can be made for all kind of elements (plant nutrients, metals), and for all types of ecosystems and scales. The purpose of nutrient balances is usually defined by the user of the nutrient balance. Three main purposes can be distinguished, i.e. (i) to increase the understanding of nutrient cycling within a system and of nutrient inputs and outputs, (ii) as performance indicator and awareness raiser in inventory and monitoring studies and in nutrient management, and (iii) as regulatory policy instrument. In many current studies, the purpose is a mixture of (i) and (ii); the studies provide information about the nutrient cycling process, contribute to the understanding of nutrient input-output relationships, and contribute to monitoring and evaluating of the effectiveness of nutrient management planning and agro-environmental policies.

There are various ways of constructing a nutrient balance, and there are various ways of collecting the information and data that are summarized in a nutrient balance. The agroecosystems under study can be very different in nature and in complexity, and these differences affect the ease and accuracy of constructing nutrient balances. Watson and Atkinson (1999) and Oenema and Heinen (1999) distinguished three basic approaches in nutrient balance studies, though there are variants within each of these:

1. *Farm-gate balance* or black-box approach; it records the amounts of nutrients in all kinds of products that enter and leave the farm via the farm-gate. The surplus, i.e. the difference between inputs and outputs, is a measure of total nutrient losses, adjusted for possible changes in the storage of nutrients in the farming system. Inputs via atmospheric deposition and biological N_2 fixation by leguminous crops are usually not included in this approach, as the inputs do not pass the farm-gate. Examples of the farm-gate approach include the MINAS regulatory nutrient book-keeping system and the OSPARCOM method (Oslo and Paris Conventions for the Prevention of Marine Pollution). In the latter example, the nutrient balance is used to monitor whether the N and P discharges into to the North Sea and Baltic Sea from the surrounding countries have decreased by 50% relative to the reference year 1985 (OSPARCOM, 1994).

2. *Soil surface balance*; it records all nutrients that enter the soil via the surface and that leave the soil via crop uptake. Inputs via atmospheric deposition and biological N_2 fixation by leguminous crops are included in this approach. Nitrogen inputs via fertilizer and animal manure are usually adjusted for losses via ammonia volatilization and other gaseous losses of N from manure during storage (as this N does not enter the soil). The surplus, i.e. the difference between inputs and outputs, is a measure of the total nutrient loss from the soil, adjusted for possible changes in the storage of nutrients in the soil. This approach is being used for example by the OECD as environmental performance indicator for agriculture (OECD, 2001).

3. *Soil system balance*; it records all nutrient inputs and nutrient outputs, including nutrient gains and losses within and from the soil. The *system approach* allows also partitioning between the various nutrient loss pathways and the storage and/or depletion of nutrients in nutrient compartments within the system. A surplus/deficit is a measure of the net depletion (output > input) or enrichment (output < input) of the system, or simply of the ‘unaccounted for’ nutrients. This approach is often used in research studies that aim at the identification of the fate of nutrient surpluses. An example is the Nutmon approach for assessing soil nutrient depletion and enrichment (Janssen, 1999).

Differences between farm-gate and soil surface balances are small for specialized crop production systems without leguminous crops and without storage of products at the farm yard. For these systems, inputs and outputs at the farm-gate and soil surface balance are roughly the same. In contrast, differences can be significant for livestock farming systems that produce roughage. These systems include crop production and animal production, with connected nutrient cycles. As a consequence, inputs and outputs at farm-gate level and at soil surface level are quite different. Nutrient surpluses differ especially for N, as ammonia emissions are included in the surplus of the farm-gate balance whereas they are not included in the surplus of the soil surface balance.

The fertilizer balance referred to in the EU Nitrates Directive can be considered as a modification of the soil surface balance. The fertilizer balance addresses total nutrient supply from all sources and nutrient demand by the crop during the growing season. When the supply by the soil is relatively small and the harvest index (harvested fraction of the crop) is large, differences between fertilizer balance and soil surface balance are relatively small. But when the harvest index is small, the differences can be large.

The data summarized in nutrient balances often have different origin. Smaling and Fresco (1993) and Smaling and Oenema (1997) indicated that the data that serve as input for nutrient balances can be classified according to (i) type, i.e. primary data, estimates, and assumptions (guesstimates), (ii) source, i.e. measurements in the field and in the laboratory, observations, and statistics (computations), and (iii) frequency of measurements and data collection, i.e. continuously, seasonally, and annually. The combination of type-source-frequency defines the data acquisition strategy. This combination depends on the purpose of the study and the nutrient balance approach. Quite often, nutrient balances are based on a combination of data types (i.e. primary data, estimates and assumptions), and the data may come from various sources and are collected at different frequencies. Farm-gate balances are usually based on primary data (and some assumptions), obtained from statistical information collected annually. By contrast, a soil system balance is usually based on a combination of primary data, estimates and assumption, obtained from continuous to seasonal measurements in the field and in the laboratory, and supplemented with statistical data and results from model simulation. Note that a comparison of balances that have been constructed for different aims may be flawed, unless underlying assumptions and differences in scale, approach, data acquisition have been considered (e.g. Schröder et al., 2003).

Box 2. Relationship between N and P surpluses and N and P losses (after Oenema et al., 2004a,b)

The N cycling and N loss pathways in agriculture are complex, especially in animal agriculture. Nitrogen is a biogeochemical highly reactive element. It prevails in nature in different species (from highly reduced to highly oxidized), different forms (solid, dissolved and gaseous) and different reactivity (from inert N_2 to reactive NO and NH_3). The cycling of N is coupled to the cycling of carbon (C), but there is decoupling of N and C at various stages of the cycle and when decoupled N is much more vulnerable to losses to the wider environment (e.g. Hatch et al., 2004).

The N surplus of the N balance sheet is a distal indicator for the total N loss. The actual fate of the N surplus depends on the N loss pathway, which is depending on the farming system and site-specific conditions. In general, the fate of the N surplus depends on the balance between N immobilization and N mineralization, on ammonia volatilization, denitrification and on N leaching to groundwater and surface waters. Losses of N via ammonia volatilization are relatively large from animal manure and urea fertilizers exposed to the atmosphere. N losses via denitrification of nitrate (NO_3^-) may occur in wet soils rich in organic matter, while N leaching losses may occur when precipitation exceeds evapotranspiration for some time. As a rule of thumb for dairy farming systems in the Netherlands, 20-40% of the N surplus is lost via ammonia volatilization, 30-60% via denitrification and 10-30% via leaching to groundwater and surface waters. The point to make here is that N surplus has to decrease by 2.5-5 kg per ha to decrease N leaching by 1 kg per ha. Similarly, for arable farms, 2-20% of the N surplus is lost via ammonia volatilization, 40-60% via denitrification and 20-40% via leaching to groundwater and surface waters. Evidently, the relationship between N surplus and N loss pathways is rather diffuse. Furthermore, there exists the risk of swapping one loss pathway to another when measures are taken to decrease one loss pathway. For example, implementation of measures to decrease ammonia volatilization may increase the losses via denitrification and leaching (e.g., Hatch et al., 2004).

The P cycle in agriculture is less complex than the N cycle. P is less reactive than N, it does not exist in different oxidation states, it is rather insoluble and its dominant form in crops, animals, manure, soils and water nature is ortho-phosphate It accumulates in soil, as organically bound P and as P bound to aluminum and iron oxy-hydroxides. Only a very small fraction in soil (<<1%) is dissolved P that can be directly taken up by the crop.

The soil is an effective sink for P applied in excess of what can be taken up by the crop, and little P is lost to the environment usually. However, the storage capacity of the soil for P is finite, and with a gradual build-up of P in soil, the soil starts to leak P from the topsoil to the subsoil to the groundwater and surrounding surface waters. The pathways of P losses from soil to the environment depend on soil conditions and the hydrological situation and are highly complex. Currently, a large acreage of agricultural land in the Netherlands has soils with a high P saturation index, which is indicative for the fact that P losses from these soils to groundwater and surface waters exceed or will exceed environmentally acceptable levels. Decreasing P surpluses will not have a strong immediate effect on P leaching, as the soil acts as buffer and will continue to leak P for some time. Hence, the soil P status or P saturation index is a more direct indicator for actual P losses from agriculture to the environment than P surpluses, but P surpluses greatly influence soil P status and the P saturation index of the soil. Various possible indicators for indicating the risk of P losses from agricultural land to groundwater and surface waters have been studied in the course of time (Sharpley at al., 2000; Schoumans and Groenendijk, 2000). All these studies emphasize that actual P losses are dependent on site-specific conditions. Further, incidental losses often have a large share in total P losses, but they are difficult to manage usually, as they are a response to extreme climate events.

3.4 EU Nitrates Directive and MINAS

41. Concerns about the use of large amounts of animal manure and fertilizers in the Netherlands have been diverse and have changed during the seventies, eighties and nineties. The approval of the EU Nitrates Directive in 1991 focused the attention very much to nitrate leaching. The Nitrates Directive obliges member states of the EU to decrease the nitrate load from agricultural sources to groundwater and surface waters, and to avoid further pollution from these sources. Member states have to (i) assign areas that are vulnerable to nitrate leaching (nitrate-sensitive zones), (ii) establish action plans to decrease nitrate leaching and to monitor the effectiveness of these plans, and (iii) develop codes of good agricultural practice to guide farmers. The core of the Directive is that a balance should be reached between N supply by soil, animal manure and fertilizers, and N demand by the crop. Further, member states have to guarantee that applications of N from animal manure do not exceed 170 kg per ha per year from the year 2002 onwards. However, a higher application rate can be allowed when justified on the basis of objective criteria, as laid down in Annex 3 of the Directive, provided that the objectives of the Nitrates Directive are achieved in time.

42. The consequences of the EU Nitrates Directive for animal agriculture in the Netherlands were underestimated initially. Upon the approval of the Nitrates Directive, there was still a belief that the manure burden could be solved using technological innovations, and that the Nitrates Directive provided enough flexibility and degrees of freedom so as to implement a regulatory system that fits agriculture of the Netherlands as long as the objectives of the Nitrates Directive were achieved, i.e., concentrations of nitrate in groundwater should not exceed the standard specified in the EU Drinking Water Directive of 50 mg nitrate per litre. This appeared to be not true, and the Netherlands' government has built up a complex dossier and a painful relationship with the European Commission as regards the implementation of the Nitrates Directive.

43. In response to the approval of the Nitrates Directive, the whole territory was assigned by the Netherlands' government as nitrate-sensitive zone. MINAS was seen as the main policy instrument for all grassland and arable and horticultural land to achieve the objectives of the Nitrates Directive, i.e., "to decrease the nitrate load from agricultural sources to groundwater and surface waters, and to avoid further pollution from these sources". Application limits for N from animal manure were not addressed in the first Action Plan (1995-1999). The Netherlands already had application standards for animal manure based on P (see section 3.2), and as the ratio between N and P in animal manure is rather narrow, the application of N from animal manure was indirectly also regulated, but this was not specified explicitly. Furthermore, the application limits for N from animal manure as set in the Nitrates Directive were considered too low and not realistic for agriculture in the Netherlands.

44. The EU Commission criticized the lack of application limits for N from animal manure and the lack of specific prescriptions and regulations for the use of animal manure and fertilizers in the first Action Plan (see also section 3.7). The responses of the Netherlands' government to the criticism of the European Commissions to the first Action Plan were diverse. One response was the implementation of additional regulations and prescriptions for the use of animal manure and fertilizers. A second response was the acceleration of the step-wise decrease of the MINAS levy-free surpluses by five years and the strong increase in the size of the levies. A third response was the application for derogation included in the Nitrates Directive, which would allow the application of a larger amount of animal manure on grassland than the maximum of 170 kg N per ha. Justification for a dose of 250 kg of N per ha from animal manure is based on the high N uptake and the long growing period of grass (Willems et al., 2000). The analyses made by Willems et al. (2000) suggests that up to 290 kg N per ha on dry sandy soils and up to 360 kg N per ha from animal manure on other soils may be applied to grassland without violating the standard specified in the EU Drinking Water Directive of 50 mg nitrate per liter in the groundwater. Scientific and policy reviews by the EU Commission expressed concerns about the size of the derogation, and challenged

the justification for grasslands on peat soils and for reseeded grassland, and thereby criticised the report of Willems et al (2000). As yet, the EU Commission has not approved the derogation.

45. A fourth response of the Netherlands' government to the criticism of the European Commissions to the first Action Plan was the implementation of the so-called manure transfer agreement system as of 1 January of 2001. Livestock farms that produce on a hectare and annual basis more N in animal manure than 170 kg per ha arable land and 250 kg per ha grassland are required to submit to the government a double-signed agreement which states that the surplus amount of animal manure is contracted by other farms that can adequately accommodate this manure. When farms with a surplus amount of animal manure are not able to submit such a manure transfer agreement by 31 December, the license for animal production for the next year is lost. The implementation of manure transfer agreements was facilitated by intermediates that organized the contacts and agreements between farms with a surplus of animal manure and farms with possibility to accommodate this manure. Farms with a surplus amount of animal manure paid for signing the agreement (goodwill fee). Annually, a large number of agreements had to be signed and verified. The amount of N in the animal manure was based on default values, which were different for different types and age of animals and animal housing systems. Whether the contracted amount of animal manure had to be transferred indeed was determined by the MINAS balance sheets.

46. The European Commission considered the responses of the Netherlands' government not sufficient. By the end of 1999, the European Commission brought the Netherlands government to the European Court, which subsequently condemned the first Action Plan of the Netherlands in its arrest released on 2 October 2003. Main arguments given by the European Court were (i) the MINAS system does not comply with the regulatory system prescribed by the Nitrates Directives, (ii) the application limits for animal manure and the levy-free surpluses set for the years prior to 2000 were too high, and (iii) essential regulations of the manure policy were implemented too late.

47. There are various subtle but essential differences in the balance approaches of MINAS and the EU Nitrates Directive. The core of the regulatory system of the Nitrates Directive is the fertilization balance at crop level during the growing season. Total N supply from soil (mineralization of organic N from soil and crop residues), atmosphere, biological N_2 fixation, animal manure and fertilizers should not exceed the total demand of a specific crop. Hence, the input of N via animal manure and fertilizers is depending on crop type, crop variety and soil type, whilst the input of N via animal manure may not exceed 170 kg N per ha per year. The fertilizer balance has to be established beforehand in the nutrient management plan that exactly states the amounts of N to be applied by the various sources. The core of the regulatory system of MINAS is also a balance between supply and demand, but the balance has to be achieved at farm level over a whole year. In MINAS, there are differences in levy-free surpluses between arable farms and dairy farms, and between dry sandy soils and other soils. Next, MINAS only considers the harvested part of the crop that is transferred from the farm, whilst the fertilization balance of the Nitrates Directive considers the total N uptake by the crop in the harvested part plus any roots, stubble, straw and any other crop residue. Further, only animal manure that is imported from other farms is explicitly recorded on the MINAS balance sheet, but the animal manure produced at the farm only implicitly itself (as the nutrients in the latter manure are part of the internal cycling within the farm. Finally, MINAS acknowledges a certain surplus (levy-free surplus), whilst the fertilization balance of the Nitrates Directive does not.

48. A strong point of the MINAS balance is that the nutrient contents of inputs and outputs is either based on standards, in case the variation of the nutrient content is small (e.g. for certified fertilizers and concentrates, but also for animals, milk and harvested crops), or on measurements (when the nutrient content is variable like in manure). This means that the surplus can be calculated quite accurately. Weak points of MINAS are that biological N_2 fixation by clover in grassland is not included and that corrections for NH_3 losses are based on standards, whereas it can differ substantially in practice depending on housing

system and management. Weak points of the fertilization balance is that the nutrient supply by soil, crop residues, animal manure, atmosphere and biological N_2 fixation can not be estimated accurately beforehand. The same is true for forecasting the total nutrient demand of the crop. As a consequence, the calculated fertilizer balance can differ significantly from reality, especially on mixed farms with crop and animal production.

49. In response to the decisions of the European Court and the European Commission, the Netherlands' government described in the third Action Plan (submitted by the end of 2003) that crop and soil specific N fertilization standards and the fertilization balance approach of the Nitrates Directive will be implemented by January 2006. At he same time, MINAS will be abandoned. Further, manure transfer agreements will be abandoned by 1 January 2005, as these have become redundant with the implementation of crop and soil specific N fertilization standards. Other reasons for dismissing manure transfer agreements are its administrative burden, high costs for intensive livestock farms and its low effectiveness. Moreover, production rights for pigs and poultry per farm, implemented earlier and which is still in practice, limit the amount of animal manure produced per farm already (RIVM, 2004).

3.5 Cost of manure disposal

50. The costs of manure disposal depend on manure supply and demand at the so-called manure market (Figure 3). When the supply of manure is large and the demand is small, the cost of manure disposal for livestock farms is high and farms that accept the manure get a goodwill fee. When the supply of manure is small and the demand is relatively large, the cost of manure disposal for livestock farms is low and farms that accept the manure have to pay for the manure. Hence, the price of the manure depends on supply and demand. The supply and demand depend on animal number, N and P excretion by the animals, application limits for animal manure, manure acceptance by arable farms, transport distance, and manure export. The ongoing tightening of the application limits from the mid 1980s onwards has increased manure supply and decreased manure demand, which has resulted in continuously increasing costs of manure disposal (Figure 2). The government has influences on the manure market by changing the limits for manure application, buying out animal production rights and by facilitating manure transport and processing, and research and extension services. In 2001-2002, the government bought out animal production rights and thereby decreased the number of pigs by about 10% at the cost of about 0.25 billion euro (35 euro per kg P; see also chapter 3.6; RIVM, 2004). In general, the cost of the production rights reflect the economic attractiveness of pig farming, and at the time of the buy-out a significant fraction of the pig farmers were willing to sell their production rights for 35 euro per kg P.

51. The costs of manure disposal rose especially after the implementation of MINAS in 1998 and following the step-wise decrease of levy-free surpluses between 1998 and 2003 (Figure 2). The cost of manure disposal for specialized livestock farmers was in the range of 5 to 15 euro per tonne; approximately 5 to 10 euro was for transport, the remainder for (arable) farmers accepting the manure. Evidently, manure disposal has become a financial burden for the intensive livestock farming systems. The costs have risen to 15,000 to 25,000 euro per farm per year in 2000-2003, while average farm income in pig and poultry production has been mainly below zero in the last five years. Currently, costs for manure disposal of more than 10 euro per tonne are considered too high for economically sustainable pig and poultry farming. The high cost for manure disposal also put pressure on the manure policy, as farmers try to find escape routes to lower costs. Manure is called 'grey manure' or 'black manure' when creative, but partly illegal, solutions were found for manure disposal at low cost. This undermines the effectiveness of the manure policy.

3.6 Additional policies to support the ecological modernization of agriculture

52. In response to the complaints by farmer unions and politicians about the drastic economic and social impacts of the manure policy on agriculture, additional policy and measures were implemented to support the objectives of the manure policy and to support the ecological modernization of agriculture. These additional policies include:

1. Action plan for nitrate projects
2. Regulation for the termination of livestock farms
3. Social economic plan for animal husbandry.

53. The action plan for nitrate projects was implemented in 1999 to support nutrient management at farm level, in order to facilitate the acceleration of the step-wise decrease of levy-free surpluses for N and P in MINAS (see chapter 3.4). The action plan includes 20 projects focused on on-farm-research, concerning validation of measures to improve nutrient use efficiency at farm level and dissemination of the results into practice. The regulation for the termination of livestock farms focused on the buy-out of animal production rights by the government to decrease the manure surplus. The social economic plan for animal husbandry focused on advising livestock farmers about future developments and about termination of farming.

54. Figure 4 shows the coherence between the instruments of the manure policy and those of the additional policy. The manure transfer agreements and animal production rights of the manure policy, together with the regulation for the termination of animal production systems and the social economic plan for animal husbandry of the additional policy are the core instruments for controlling total manure production and disposal. Control of manure production at national level is a prerequisite for achieving proper balance between inputs and outputs of N and P at individual farms through the core instruments MINAS and supported by additional regulations for the use of manure and fertilizer (code of good agricultural practice) and by the Action plan for the nitrate projects. All together, these instruments are meant to achieve the national emission targets and environmental quality objectives, as well as the objectives of the EU Nitrates Directive.

3.7 Social and political backgrounds of the manure policy

55. The initial denial of the manure problem after its recognition by scientists in the late sixties and the subsequent postponement of effective measures was possible because the agricultural–policy community was strong and relatively insulated. Membership of the agricultural–policy community was restricted to leading farmers, experts from the Ministry of Agriculture, the farmers unions as well as members of the Parliamentary Committee on Agriculture. This group constituted a network of close mutual relationships and had a degree of interchange ability. They shared a firm belief in technical progress and modernization of agriculture (Frouws, 1997). During this initial period of manure policy making, the Ministry of Agriculture, supported by the farmers' lobby, succeeded in giving a definite agricultural emphasis to all legislation. The Ministry of Environment, which was not supported by a firm policy community, had to accept a manure policy based on existing livestock numbers. The taboo on reducing the intensive livestock sector affected all ensuing regulations, which allowed sufficient time and money so as to adapt farming methods and to develop technologies to reduce and absorb the manure surpluses. The decision was taken to develop manure legislation in three phases (see Section 3.2).

56. However, the manure policy became more restrictive with time and as a consequence produced conflicts between the Ministry of Agriculture and farmers' unions, and later also between farmers' leaders and farmers unions. The farmers' lobby disputed essentially all regulations and the legitimisation of the negotiated policies was frequently unsuccessful. The controversies within and between farmers' unions

caused a split between regions with manure surpluses and regions with manure “shortages”. The question came down to a single issue: who was to blame for the manure surplus and the ensuing pollution and who had to pay for it. The dispute about this basic question was also a major factor for the failure to set-up industrial manure processing and export facilities; the farmers’ unions and the livestock sector itself were unable to realize the necessary socio-economic conditions (Frouws, 1997). The lack of large-scale manure processing and export of processed manure heavily mortgaged the third stage of the manure policy, which should have been implemented between 1995 and 2000.

57. The preparation of the third phase of manure legislation, which was to bring about balanced fertilization, was a painstaking process. It started in 1991. In 1993, the Ministries of Agriculture and Environment, and the central farmers’ union agree upon choosing the mineral accounting systems as basic principle for the third phase of the manure policy. Provisional sizes of levy-free N and P surpluses were mentioned and it was agreed that these sizes would decrease stepwise until balanced fertilization was reached in 2000. The farmers union LTO emphasized that too stringent levy-free surpluses would be disastrous to the competitiveness of the livestock sector and that much research was still needed to determine the ultimate sizes of levy-free surpluses. This delaying strategy was partly inspired by the failure of large-scale manure processing and export, and the looming danger of a huge manure surplus, which would make a drastic reduction of animal numbers inevitable. Finally, in October 1995, the lay-out of the 3rd phase of the manure policy and of the nutrient accounting system was send by the Ministries of Agriculture and Environment to the Parliament for approval.

58. The third phase of the manure marks a shift in the philosophy of the manure policy. Firstly, there was a shift from prescription and do’s and don’ts measures towards realizing targets, i.e., a shift from regulation towards stimulation. Secondly, it was stated that social support by farmers for the new policy is crucial, because farmers need to comply with the policy. Otherwise the policy can not be enforced. Thirdly, it emphasizes the importance of entrepreneurship, differentiation and technological innovation. A general and uniform policy for all farms and soils is ineffective; a farm-specific nutrient accounting systems is needed. MINAS was born. Together with the launching of MINAS in October 1995, it was mentioned however, that the foreseen levy-free surpluses of MINAS would be not sufficient for realizing the nitrate limit of 50 mg per litre in the upper groundwater of well-drained sandy soils in time. It was also mentioned that MINAS as instrument was different from that of the EU Nitrates Directive, and that negotiations would be needed with the EU Commission.

59. The Nitrates Directive was approved by all member states of the EU on 12 December 1991, under the presidency of The Netherlands. Approval had been a complex and painful process. The Netherlands’ government indicated in a letter to the EU Commission in March 1989 that the whole territory of the Netherlands needed to be designated as vulnerable to nitrate leaching. Further, it was emphasized in the letter that member states should have the freedom of choice of selecting proper measures. Two bottlenecks were envisaged; (i) the speed of implementation was not acceptable, the Netherlands’ agriculture needed more time to adjust to the new legislations, and (ii) the limits for the application of animal manure were too low. Despite these serious concerns, the Netherlands’ government approved the Nitrates Directive. Approval has been explained by the facts that environmental issues were high on the political agenda and that the Netherlands had positioned itself as fore-runner in the field of environmental policy. Evidently, not approving the Nitrates Directive would have led to loss of face (Van Bavel et al., 2004).

60. The first action plan, needed in the framework of the Nitrates Directive, was submitted by the Netherlands government to the EU Commission in December 1995 (see also Section 3.4). Emphasis in this action plan was on achieving objectives in stead of complying with limits for the application of animal manure. It was stated that objectives of the Nitrates Directive would be achieved for the largest part of the territory by 2010 (which is 7 years after the final date mentioned in the Nitrates Directive). Attached to the

action plan was a request for derogation; a request to apply 250 kg of N per ha via animal manure to all grasslands instead of 210 kg per ha according to the Nitrates Directive. The EU Commission did not respond positively to the action plan. As a result, The Netherlands' government withdrew the action plan and submitted a revised version two years later in December 1997.

61. The Commission noted various shortcomings in the revised action plan, as formulated in a formal letter to the Netherlands' governments on 29 September 1998. This led to various changes in the manure policy of the third phase, such as the introduction of the manure transfer agreements in 2000 (see also Section 3.4), tightening of levy-free surpluses and acceleration of its implementation (from 2010 to 2003). However, the Commission found these changes inadequate and too late. By the end of 1999, the European Commission brought the Netherlands government to the European Court, which subsequently condemned the first Action Plan of the Netherlands in its arrest released on 2 October 2003. The Dutch government accepted this view, and submitted two months later the third Action plan, now with application limits for animal manure and fertilizer as instruments for regulation of N and P in agriculture, in conformity with the Nitrates Directive.

62. Many questions have been raised following the sudden death of MINAS. What has been the role of the various actors involved in the implementation of MINAS as instrument to achieve the objectives of the Nitrates Directive? What went wrong? Why now? What are the alternatives? It is clear that The Netherlands government has underestimated the importance and consequences of the Nitrates Directives. For too long, MINAS was advocated as the superior instrument, and for too long it had not properly addressed the questions of the European Commission. Negotiations have been a clash of views and approaches; the juridical approach of the Commission with regulations as prime instrument, against the managerial approach of the Netherlands government with economic stimulation as prime instrument. There was also distrust by the Commissions about the willingness of the Dutch government to fully implement the Nitrates Directive (Van Bavel et al., 2004; Box 3).

63. The very rapid erosion of MINAS was not only the result of the judgement of the European Court, but also because of the many complexities of MINAS and the increasing administrative costs with time (e.g. RIVM, 2004; Mallia and Wright, 2004). Pig and poultry producers faced huge levies, because of exceeding the levy-free N and P surpluses. This appeared to be caused in part by inaccuracies in the standard figures used to determine the N and P content of pigs. The radical pig farmers union was strongly opposing against MINAS from the beginning onwards and unfair levies were used as basis for litigation proceedings against the government, disputing the outcome of MINAS balances sheets. MINAS met opposition from within the pig sectors because it adversely affected the economic standing of the pig producers. The MINAS levies were prohibitive, as were the manure transport costs that would be incurred in order to avoid the levies. MINAS provided no incentive for pig farmers to save money through lowering the N and P contents of the animal feed, which would have environmentally beneficial effects. MINAS was seen as a very expensive administrative burden, which did not produce any environmental beneficial result, and this undermined the legitimacy of MINAS. There were also inaccuracies involved in the sampling and analyses of animal manure. The Levies Office was forced to deal with increasing number of complaints and refusals to pay. The inaccuracies in standard figures resulted in the Legal Office being required to backdate all MINAS returns for pig farmers since the introduction of the policy, which increased the bureaucratic burden. They granted the farmers a credit, which in practice meant that pig farmers did not have to dispose of so much manure. According to MINAS, this 'grey manure' did not exist, and therefore there are no controls in place for its disposal. These outcomes had an undermining effect on MINAS. The administrative costs of MINAS increased with time as a direct result of exceptions, fraud, and exploitation of loopholes in the system by pig and poultry farmers. The ongoing court procedures, the increased bureaucratic burden, and the absence of environmental beneficial effects in the pig and poultry sectors have demoralised the policy makers and the controllers at the Legal Office (Mallia and Wright, 2004).

64. Evidently, there is no single reason why MINAS eroded so quickly.

Box 3: Role of actors involved in the implementation of MINAS as instrument to achieve the objectives of the Nitrates Directive (after Van Bavel et al., 2004)

Ministry of Rural Planning and Environment VROM

- Responsible for the implementation of the Nitrates Directive and therefore principal negotiator with the EU Commission
- Has strong focus on safeguarding the environmental good
- Had difficult relationship with the Ministry of Agriculture in the second half of the 1980s, but this relationship improved much when the manure policy became the joint responsibility with the Ministry of Agriculture

Ministry of Agriculture Nature and Food Quality LNV

(Earlier: Ministry of Agriculture and Fisheries).

- Responsible for agricultural policy and the manure policy (together with VROM); implementation of the Nitrates Directive and therefore principal negotiator with the EU Commission
- Underestimated the consequences of Nitrates Directive initially
- Put focus on proper balance between minimizing the social-economic consequences of the manure policy and achieving environmental objectives.

Parliament

- Responsible for decisions about implementation of the manure policy
- Has strong focus on national situation, and on minimizing the consequences of the Nitrates Directive for agriculture;
- Has been motor for the slackening of MINAS
- Has restricted the degrees of freedom of the ministries of LNV and VROM to act in the negotiations with the Commission

The Dutch government

- Until 1994 dominated by the Christian Democratic Party, CDA, which has many farmers as voters, and the Liberal Party VVD.
- From 1994 to 2002 dominated by the Social Democratic Party, PvdA, and the Liberal Parties VVD and D’66;
- From 2002 to present dominated by the Christian Democratic Party, CDA, and the Liberal Parties VVD and D’66.
- Strong managerial approach (and little juridical);
- Did not have much attention for the juridical culture and views of the Commission
- Minister of Agriculture is a painstaking job, because of the manure policy;

European Commission

- Powerful position relative to the Netherlands government with respect to the Nitrates Directive, as the Netherlands had approved the Nitrates Directive;
- Strong juridical approach in the negotiations;
- Considers reduction of animal number in the Netherlands’ agriculture necessary to be able to comply with Nitrates Directive;
- Considers MINAS a very complex piece of regulation with lots of exceptions;

European Court

- Agreed completely with the view of the European Commission with regards to the first action program, which was not expected by the Dutch government

Farmers’ union LTO

- Represents the social-economic interests of very divers farmers groups
- Proposed many exceptions for various farming systems in MINAS, in response to the diversity of interest groups;
- Has no common view on MINAS, because of the diversity in farmers interests
- Dominated by dairy farmers and building on consensus, which among others led to the separation of the radical pig farmers union in 1994, and later also of the arable farmers union and the dairy farmers union which all proposed a more radical approach to fight governmental regulations.

Green action groups

- Did not have much influence on Parliament and the Ministries of Agriculture and Environment initially;
- Started a juridical procedure against the Royal Kingdom of the Netherlands, because of the non-compliance to the Nitrates Directive;
- Established good relationship with the European Commission, gave background information to the European Commission, and thereby had strong influence on the European Commission

Research organizations

- Identified the manure surplus, which basically is a nitrogen and phosphorus surplus
- Supported the ministries of Agriculture and Environment with information and suggestions
- Independence of some researchers has been questioned by green action groups and also the European Commission, because of the funding by the Ministries of Agriculture and Environment and because of the limited number of refereed publications in international scientific journals about MINAS and the Nitrates Directive.

4. Technical, economical and environmental effects of the manure policy

65. The manure policy provides strong incentives to better utilize N and P in crop and animal production so as to decrease N and P surpluses. Better utilization of N and P from animal manure involved manure transport from areas with excess amounts to areas with little manure, next to improvement of nutrient management in crop and animal production. MINAS has been the core instrument behind the improvement of nutrient management and the better utilization of N and P in crop and animal production from 1998 onwards. The effectiveness of MINAS follows from the estimation that 80% of the decreases in N and P surpluses during the period 1998-2003 is the result of the manure policy and 20% of other polices and autonomous developments (RIVM, 2004)

66. In the first phase of the manure policy (see chapter 3.2), decreases in N and P surpluses at farm level were largest on specialized pig and poultry farms, as these farms were forced to transfer animal manure to other farms. In the third phase of the manure policy (form 1998 onwards), decreases in N and P surpluses at farm level were largest on dairy farms, following the implementation of MINAS. From the beginning of the manure policy, decreases in N and P surpluses were least in arable farming. The differences between these sectors are discussed further below.

4.1 Dairy farms

67. Average surpluses of N and P on dairy farms have decreased by more than 50% within a period of 15 years, i.e., by on average 3 to 5% per year. This decrease is the combined result of the implementation of milk quota in 1984, the mean increase in milk production per cow by about 1-2% per year, and the manure policy (e.g., Van Bruchem et al., 1999; RIVM, 2002; 2004). The largest decrease took place in the period 1998-2003 following the implementation of MINAS. Various individual farmers were able to lower the surpluses of N and P by 50% even within two years, when supported by direct guidance of advisors and researchers. Discussion groups of farmers were also helpful, as farmers learn from each others experiences.

68. Though the decrease of N and P surpluses went rapidly following the introduction of MINAS, it went not for all dairy farms rapid enough to keep up with the decreasing levy-free surpluses. The mean decrease in N surplus of dairy farms tended to be lower than the decrease in the levy-free surplus. Whilst the mean decrease in levy-free surplus ranged from 18 to 20 kg N per ha per year in the period 1998-2002, the decrease of the N surplus ranged from a mean of 14 kg per ha per year on ‘intensive’ dairy farms to a mean of 21 kg per ha per year on ‘extensive’ dairy farms. The mean decrease of pilot farms was in the range of 20 to 35 kg per ha per year. There were large differences between farms (RIVM, 2004).

69. The decreases in N surpluses were less over the period 2000 - 2002 than over the period 1998-2000, when the N surplus decreased by 30 to 50 kg per ha per year. Evidently, the easy-to-implement and most cost-effective measures were implemented already in the period 1998-2000 and before. A further decrease of the N surplus beyond the initial rapid decrease appears much more difficult and takes more time. A number of dairy farms had achieved the levy-free surpluses for the year 2003 already by 2001 or 2002. As a consequence, there was no incentive for these farms to decrease the surpluses further.

70. On average 85% of the ‘extensive’ dairy farms and 65% of the ‘intensive’ dairy farms met the levy-free surpluses for N and P in 2000 and 2001. Hence, 15% and 35% of the dairy farms had to pay levies, respectively (RIVM, 2004). However, the exceedance of the levy-free surpluses for N and P, and hence the levies paid were relatively low. On the other hand, a significant fraction of the dairy farms already met the levy-free surpluses of 2003 in 2001 and 2002. Most dairy farms did not have difficulties with meeting the levy-free surpluses for P, though it must be kept in mind that P fertilizer is not included in the accounting (see chapter 3.4).

71. Dairy farms took various measures in response to MINAS. A common measure was a decrease in the use of N fertilizer. Purchase of land, and lowering the number of young stock were also common measures. On average, dairy farms did not feel large economic disadvantages following the implementation of MINAS. Various farms noted beneficial economic effects of MINAS, through better (nutrient) management (RIVM, 2004).

4.2 Pig and poultry farms

72. Most pig and poultry farms are highly specialized. Essentially, these farms import all feed for their animals, whilst the land is used for manure disposal and growing silage maize for surrounding dairy farms. With the implementation of MINAS from 1998 onwards and the step-wise decrease of the levy-free surpluses, these farms had to transfer more and more animal manure to other farms, which could accommodate less and less animal manure in time. Currently, these farms have to transfer roughly 80% of the animal manure to elsewhere, whilst 20% can be applied to the land of these farm (on average about 10 ha per farm; in total 5% of the total acreage of agricultural land).

73. The costs of the manure policy are high for specialized pig and poultry farmers. The costs for manure disposal have steadily increased in the period 1985 to 2003, and were in the range of 15,000 to 25,000 euro per farm in 2000-2002. These costs were about 3-6% of the total costs of these farms. Expressed in percentage of farm income, the costs for manure disposal were very large, as average income was negative due to the poor economic situation for pig and poultry sectors in this period.

74. Specialized pig and poultry farms faced significant difficulties with MINAS following its implementation in 1998. Firstly, surpluses of N and P on specialized pig and poultry farms greatly vary between years, simply because of variations in stocks of animals, animal feed and animal manure at the end of the MINAS accounting year. Variations in stocks of animals, animal feed and animal manure are not included in the MINAS balance. Because of the large effects of these variations, the government introduced the possibility of clearing variations in N and P surpluses over years. Secondly, surpluses of N and P are expressed per unit of surface area per farm. As the surface area of these farms is small and the total input and output of N and P very large, calculated surpluses of specialized pig and poultry farms are very sensitive to small errors in input and output items (like errors in the measurements of N and P contents in animal manure transferred from the farm) of the MINAS balance sheet. This led to substantial over and under estimations of surpluses. Thirdly, there were errors in the official fixed N and P contents of animals initially. These errors were relatively small, but because of the large number of animals, the total annual error per farm was large. Fourthly, some farms had large stocks of animal manure in storage basins with P-rich sediment layers in 1998 when MINAS was implemented. All these complications did not ease the implementation and acceptance of MINAS by pig and poultry farmers. These farmers are in general well-organized in unions and against (environmental) regulations, more than dairy and arable farmers.

75. Sampling of animal manure and analysis of its N and P content remains a complicated issue. Animal manure is very heterogeneous, requiring thorough mixing before taking a representative sample, and special fraud proof equipment for sampling has to be used by the accredited transporters. Yet, there are

slight inaccuracies involved and there are also both systematic and random differences between different accredited laboratories in the determined N and P contents of the animal manure.

76. In 1998-2000, pig and poultry farms had to pay high levies for exceeding the levy-free surpluses. On average, they had to pay 4000 to 5000 euro per farm. More than 200 farms received a levy of more than 45,000 euro in 2000, while 1400 farms received a levy of 15,000 to 45,000 euro. On average 60% of the specialized pig and poultry farms met the levy-free surpluses for N and P in 2000 and 2001 (RIVM, 2004).

4.3 Arable and horticultural farms

77. With a few exceptions, specialized arable and horticultural farmers have not faced much influence of the manure policy so far. The first and second phases of the manure policy (Chapter 3.2) addressed especially animal farming. Though the application limits for animal manure and the code of good agricultural practices addressed all farms, the influence on arable farms was small. The third phase, with the implementation of MINAS on all farms from 2001 onwards, involved arable and horticultural farmers directly with the manure policy. Initially, there was opposition among arable and horticultural farmers as they felt to be saddled up with the problems of intensive livestock farmers. They considered the bureaucratic burden of N and P accounting useless, a waste of time and a curtailment of their freedom. Partly in response to their complaints, fertilizer P was excluded from the MINAS accounting, and the fixed defaults values for N and P in harvested products were set relatively high.

78. More than 90% of the arable and horticultural farms met the levy-free surpluses in 2000-2003 (RIVM, 2004). Basically, there have been no large changes in N and P surpluses in arable farming, except for some intensively managed horticultural farms, farms with a side branch of pig or poultry production, and farms that import relatively large amounts of animal manure from adjacent pig and poultry farms. In some areas, the surpluses of N and P have slightly but steadily increased during the last 15 years, because of the attractiveness of accepting animal manure from livestock farms.

79. On average, arable farms have benefited financially from the manure policy. Depending of the balance between supply and demand of animal manure (see Chapter 3.5), arable farmers received 0-5 euro per tonne of animal manure accepted from livestock farms, equivalent to about 1000 euro per farm. In addition, arable farms got paid for signing manure transfer agreements (see Chapter 3.4), which was equivalent to about 750 euro per farm. Moreover, the costs for fertilizer purchases decreased. All together, these benefits compensated to some extent the loss of income of arable farmers due to the decrease in the price support by the EU following the reform of the CAP.

4.4 Changes in fertilizer use and net loading of the soil at national level

80. On a national level, fertilizer N use decreased by 29% (116 million kg N) and fertilizer P use by 22% (6 million kg P; 14 million kg P_2O_5) in the period 1998-2002. These decreases are equivalent to a mean of 11 kg N per ha per year and a mean of 0.6 kg P per ha per year. Dairy farms had by far the largest share in this decrease, while the contribution of arable farms was negligible.

81. The total amount of N in animal manure has decreased by 22% (134 million kg N) and that of P by 9% (8 million kg P; 18 million kg P_2O_5). About 50% of this decreased was realized in the dairy farming sector, as a result of fewer dairy cows and young stock, and as a result of the lower protein content of the animal feed. The other 50% was realized in pig production. Between 1990 and 2002, the total amount of P in pig manure decreased steadily from about 30 to 20 million kg P per year as a result of a lower P content in the animal feed and a decrease in pig number (following diseases, the poor economic situation for pig production, and the buy-out of animal production rights by the government in 2001-2002). The total

amounts of N and P in poultry manure have not changed much over the last ten year; the total amount of P ranged between 15 and 17 million kg P per year.

82. The total amount of P in intensive livestock production (pig, poultry and veal production) decreased from 44 million kg P in 1994 to 36 million kg P in 2002. Approximately 20% of the manure produced by pigs and poultry in 2002 was disposed on own land, 30% was processed and exported to other countries, and 50% was transferred to other farms in the Netherlands. In total about 8 million kg P was processed and exported to other countries, mostly poultry manure. The amount exported to other countries has steadily increased over the last decade. , suggesting in part that the room for disposal of manure at other farms in the Netherlands has diminished in this period. The potential total room for manure disposal within the Netherlands has been utilized for about 80% in 1998-2002, but in some areas it was (more than) 100%.

83. In the period 1998-2002, the total net loading of the soil with N and P has diminished by 35% (169 million kg N) and 33% (18 million kg P), respectively. The mean net loading of the soil with N was 240 kg per ha in 1998 and 155 kg per ha in 2002. Similarly, the mean net loading of the soil with P decreased from 31 kg P per ha in 1998 to 20 kg P per ha in 2002. The decreased in N loading was caused predominantly by the decrease in the use of N fertilizer and the amount of N in animal manure. The decrease in P loading was caused by a combination of the decrease in the use of P fertilizer, the decrease in the amount of P in animal manure and the increase in the export to other countries of P-rich poultry manure. The purchase of P fertilizer has steadily decreased from 1950 onwards, in response to the increased amount of animal manure and the steady increase in the P status of agricultural soils. The relatively poor economic situation in arable farming has also contributed to the decrease in the use of P fertilizer. There was no change in withdrawal of N and P with harvested arable crops, suggesting that the decreased input of N and P via fertilizers and animal manure did not yet affect yield and N and P contents of the marketed crops. The N content (protein content) of herbage (grass) did decrease significantly.

4.5 Changes in N and P losses to groundwater, surface waters and atmosphere

84. Nitrate concentrations in the shallow groundwater are related to the net N loading of the soil, but the relationship between net N loading of the soil and nitrate concentration in the groundwater differs greatly between soil types, and is also strongly affected by weather conditions (rainfall). Nitrate concentrations are highest on well-drained sandy soils with relatively deep groundwater level, medium high on clay soils, and lowest on peat soils with shallow groundwater level. The differences are related to N losses via denitrification (see Box 2). Measured nitrate concentration in the upper groundwater of well-drained sandy soils decreased from a mean of 134 mg per litre water in the period 1992-1995 to a mean of 76 mg per litre in the period 2000-2002, suggesting that the manure policy was effective in decreasing nitrate concentrations in groundwater of well-drained sandy soils. Rather similar decreases were noticed on clay soils. Nitrate concentrations in the groundwater of peat soils with shallow groundwater remained unaffectedly low.

85. Nitrogen concentration in surface waters decreased slowly but steadily in the period 1998-2002, suggesting that the manure policy was effective in decreasing N concentrations in surface waters. There was no change in the concentration of P in the surface water. The lack of a change in P concentration in the surface waters is probably related to the fact that the agricultural soils remained unaffectedly rich in P, and that P losses from soil to surface waters are more related to the soil P status than to net loading of the soil with P (see box 2).

86. Between 1995 and 2002, emissions of ammonia (NH_3) and nitrous oxide (N_2O) from agriculture into the atmosphere have decreased by 30% (56 million kg) and 18% (5 million kg), respectively. Between

1985 and 1995, NH_3 emissions decreased already by 63 million kg, following the implementation of various techniques for low-emission storage and application of animal manure.

87. Though the environmental quality of groundwater, surface waters and atmosphere improved following the implementation of the manure policy, and especially after the implementation of MINAS 1998, environmental quality objectives for groundwater, surface waters and atmosphere have not been achieved yet.

4.6 Forecasting environmental effects of lowering N and P surpluses

88. Various studies have been carried out to explore the effects of more stringent levy-free surpluses and of smaller N and P loading of the soils on environmental quality. This section summarizes some of these results of model calculations (see also Annex 1).

89. Lowering levy-free N surpluses decreases the concentrations of nitrate in the upper groundwater. Decreases are most significant for well-drained sandy soils, vulnerable to nitrate leaching. Nitrate concentrations in the upper groundwater of well-drained sandy soils decrease from a mean of 100-150 mg per litre when levy-surpluses for N are in the range of 100-150 kg per ha for arable land and 190-220 kg per ha for grassland to a mean of 50-100 mg per litre when levy-surpluses for N are in the range of 40-60 kg per ha for arable land and 100-140 kg per ha for grassland. Mean concentrations in sandy soils appear higher for maize land than for grassland, though levy-free N surpluses are lower for maize land than for grassland. Relatively high nitrate concentrations in maize land have been ascribed to residual effects of heavy manure applications in the past (net mineralization). It has been suggested that low levy-free N surpluses in combination with additional measures, such as cover crops on maize land in winter and restricted grazing of grassland in autumn, are needed to lower nitrate concentrations in the upper groundwater of dry sandy soils to below 50 mg per liter (RIVM, 2002; Oenema et al., 2003; 2004a,b).

90. Lowering the levy-free N and P surpluses decreases the leaching of N and P to surface waters. The relative decreases are less than the relative decreases in mean levy-free N and P surpluses and in mean net loading of the soil with N and P. This apparent ineffectiveness of decreasing leaching of N and P to surface waters by lowering levy-free N and P surpluses at farm level has been attributed to:

1. Spatial effects: the discharge of excess rain water to surface water is largest in the northern and western half of the country, where the decrease in net loading of the soil is less than in the southern and eastern half (because of differences in land use and farming practices);

2. Contribution of background leaching: nutrient-rich seepage from the marine and riverine subsoil is 30 to 40% of the total leaching losses from soils to surface waters, and this seepage is assumed to be invariable of variant; and

3. P leaching is primarily related to the P saturation index of the soil, which is also nearly invariable of variant in the short term considered here (but not in the long term).

91. Lowering levy-free N surpluses also decreases the mean emissions of NH_3 and N_2O to the atmosphere also significantly, but relative decreases are less than the relative decreases in levy-free surpluses.

92. The results of such explorative studies have been used by policy makers to find out the levy-free N and P surpluses that comply with environmentally acceptable N and P losses for various soil type and land use combinations. The studies help to explain the complex relationships between levy-free N and P surpluses and environmental quality. The studies can also help to identify areas where additional measures are needed. However, the uncertainty in the model explorations is often larger than policy makers can

accept. This is especially the case for nitrate leaching on sandy soils. Forecasting a mean nitrate concentration of 50 mg per litre with an error bar of 20 mg per litre in the upper groundwater of well-drained sandy soils in the Netherlands may be a good achievement from a scientific point of view. But the practical consequence is that the levy-free N surplus may be set too low (from the farmers' perspective) or too high (from an environmental point of view and from the perspective of Brussels), depending on the deviation.

4.7 Costs and benefits of the manure policy

93. Total annual costs of the manure policy for farmers have rise steadily from essentially zero in 1984 to about 200 million euro in 1998 and further to 400 million euro 2002. Major costs were related to facilities for manure storage and manure disposal and administration. The increase in annual costs from 1998 onwards was related to increased costs for manure disposal and administration associated with the implementation of MINAS. The total administrative costs for farmers have been estimated at 155 million euro per year in the period 1998-2001. The total costs for farmers have been corrected for any beneficial effects, such as lower costs for fertilizer purchase (35 million euro) and goodwill fee for manure acceptance (RIVM, 2004).

94. Levies paid (on average 13 million euro per year) for exceeding levy-free surpluses are not included in the costs, as these levies are not withdrawn but returned to the common balance of the government. The imposed levies for exceeding levy-free surpluses steadily increased from 40 million euro in 1998 to about 200 million euro in 2002. However, the collected levies remained more or less constant and were on average 13 million euro per year. Main reasons for this difference is the introduction of the opportunity for averaging surpluses over years (compensation through under spending levy-free surpluses in following years), and delays in payment due to time-consuming objections. Evidently, levies for exceeding levy-free surpluses have not been large costs for farmers so far (RIVM, 2004).

95. The total cost of the manure policy for the government (or tax payer) has been significant. The annual cost for implementation and enforcement of MINAS, manure transfer agreements and animal production rights increased from 18 million in 1998 to 86 million euro in 2002. The non-recurring cost of the action plan of nitrate projects was 60 million euro. Total non-recurring cost for the buy-out of animal production rights was 255 million euro. Non-recurring cost for other buy-outs was 99 million euro and for additional structural measures 356 million euro. Total non-recurring cost of the structural adjustments was 710 million euro (RIVM, 2004).

96. The cost for purification of groundwater with too high concentrations of nitrate has been estimated at 16 million euro per year. The average annual cost spent for combating the effects of eutrophication caused by agriculture in the Netherlands has been estimated at 7 million euro per year, but the effects are as yet unclear. If the manure policy becomes fully effective, these costs for purification will become smaller (RIVM, 2004).

97. The decrease in net loading of the soil with N and P can be considered as the main benefit of the manure policy. Between 1998 and 2002, the net loading of the soil decreased by 169 million kg per year for N and by 18 million kg per year for P (chapter 4.4). Using these data it follows that the net loading of the soil decreased by about 0.2 kg P and 0.8 kg N per euro spent (RIVM, 2004). The cost of removal of N and P from surface waters are much higher (Chardon et al., 1996).

5. Discussion and Conclusions

98. Awareness of the negative side-effects of intensive agricultural production in the 1970s and 1980s marks a major change in the relationship between agriculture and society. Traditionally, agriculture

was a major source of natural values and according to Lowe and Ward (1997) a mediator of natural morality. The imposition of many regulatory controls has in part stigmatised farmers as environmental criminals, especially in countries with high livestock density, and as a consequence, environmental pollution by agriculture has become to some extent a politicised problem. Restoration of natural values and the multi-functionality of the rural area are needed to give farmers the position in the society that they used to have.

99. The MINeral Accounting System MINAS implemented in 1998 in the intensive animal agriculture in the Netherlands is designed in accordance with eco-modernist thinking. In response to many measure-oriented and rather ineffective command-and-control regulations implemented in the 1980s and first half of the 1990s, there was a quest for a target-oriented, integrated and flexible economic instrument for decreasing nutrient losses. MINAS gave farmers the responsibility and the freedom to choose the optimal way to realize the targets of the manure policy and to solve the nutrient problem of their farms. MINAS is designed with the aim of increasing the efficiency of nutrient utilization at all farms, and at the same time to drastically decrease nutrient losses. Through the application of a levy to surpluses exceeding the levy-free surpluses, the MINAS instrument is perceived as a steering mechanism for directing farmers' behaviour along more environmentally benign pathways. It presumes that farmers behave economically rational and that the economic incentive provided by the levy will lead to the implementation and acceleration of technical and technological changes and management improvements at the farm to increase the efficiency of nutrient utilization.

100. Implementation of MINAS implied that the environmental cost of over-use of nutrients is internalised in the decision making and economic costs of farming. Animal farmers have to feed the animals and to fertilize the crops closer to the edge of what is possible. They have to invest in for example manure storage facilities, manure applicators and manure disposal. Some of these changes appeared to be economically neutral or even beneficial, like nutrient management changes that do not require investments. Changes requiring investments, and especially manure transfer to other farms, are economically negative (RIVM, 2002; 2004). Low-emission techniques increased the costs for manure application by 2 to 5 euro per tonnes of animal manure. The annual cost of manure disposal for pig and poultry farms in the Netherlands had increased to more than 10,000 euro per farm (Figure 4). The annual costs associated with the administration of the MINAS farm-gate balance are estimated at 1,500 euro per farm. In addition, levies for N and P surpluses exceeding the levy-free surpluses have been imposed on many farmers, but few have paid these levies so far. All these costs impair the profitability of animal farming, especially of pig and poultry farming. On the other hand, these economic costs provide the incentive for improving farming practices and for increasing the efficiency of N and P use at farm level (RIVM, 2002; 2004).

101. Implementation of a nutrient balance at farm level with levies on N and P surpluses that exceed predetermined levy-free surpluses provide strong incentives to improve N and P use efficiency at farm level and thereby to decrease nutrient losses to the wider environment. It is an integrated instrument, in that it decreases all N and P loss pathways. In theory, N and P balances at farm level is the best instrument for decreasing total N and P losses from agriculture. It is meant to be fair, because it directly addresses N and P surpluses at farm level (polluter-pays principle). It is meant to be environmentally effective, because N and P use is improved and thereby total N and P losses are decreased. There are no substitutes for N and P as nutrients that would allow circumventing possible levies. It is meant to be economically efficient, as it is up to the farmer to decide which measures are cost-effective, practical and convenient to lower the N and P surpluses to the level of the predetermined levy-free surpluses. However, it does not provide an economic reason for farmers to continue to implement changes and innovations aimed at further decreasing N and P surpluses once levy-free surpluses have been achieved.

102. The two recent fact-finding studies (RIVM, 2002; 2004) conclude that in practice MINAS is an effective and efficient instrument for decreasing N and P surpluses from dairy farming. Dairy farming

covers more than 60% of the agricultural land and has a large share in total N and P surpluses in agriculture and in total N and P losses to the wider environment. Dairy farming is partly land-based and there are various possible ways of decreasing N and P surpluses environmentally effective and economically efficient. MINAS is an effective management instrument for integrated strategic nutrient management planning in dairy farming. Most dairy farmers have learned more about integrated nutrient management during three years of MINAS than during 10 years or more of using fertilizer recommendations and so-called fertilization balances.

103. MINAS is considered to be not a proper instrument for pig and poultry production (RIVM, 2002; 2004). It is fundamentally flawed for intensive animal production systems that have little land and import basically all animal feed, because MINAS expresses surpluses in units per surface area, and does not address variations in N and P stocks in animals, animal feed and animal manure (see also Chapter 4). A lot of effort has been made in practice to improve the accuracies of sampling and analyses, but the inaccuracies that remained are larger than MINAS can afford.

104. Further, MINAS has not proven yet to be effective for arable and horticultural farming, simply because P fertilizer was excluded from accounting, the fixed defaults for N and P in harvested crops were set at a (too) high level, and N and P surpluses at most farms were already below the levy-free surpluses. In theory, MINAS could also be an effective and efficient instrument for arable farming, if the fixed default values for N and P in harvested crops were made crop-rotation specific, P fertilizer was included in the accounting and the levy-free surpluses were adjusted to environmentally sound levels.

105. The results of the fact-finding studies (RIVM, 2002; 2004) also indicate that farmers need time to adopt new techniques and management styles to adjust to improved farming practices following the implementation of MINAS. They have to learn and they have to be convinced of the need for change, otherwise they remain reluctant to change and ignorant of improved practices. Direct guidance, demonstration farms and pilot farms are essential in this respect. On the other hand, government and governmental institutions also need time to learn and to fine-tune the instrument to the reality and complexity of the real-world (institution building). Initially, there were some errors in the fixed default values and these had to be adjusted. Also the size of the levy-free surpluses and the size of the levies have been frequently adjusted. Evidently, there need to be a balance between the step-wise lowering of the levy-free surpluses and the possibilities of farmers to adjust farming practices so as to lower the N and P surpluses to the level of the adjusted levy-free surpluses.

106. The manure policy of the Netherlands is a complex policy that addresses a stubborn and complicated problem. The manure policy has a history of almost 20 years of changes, successes and failures. The N and P accounting system MINAS implemented at farm level in 1998 has been the core instrument of the third phase of the manure policy, and marks a shift in the manure policy from regulations and measure-oriented policies towards target-oriented policies with stimulations via economic incentives. Though MINAS is an integrated and flexible instrument and in principle applicable to all farms, the differences between sectors are so large and the complexity of the manure problem is so big that there is no single instrument that can solve everything at once. Additional instruments have been implemented to support the manure policy, but not all of these additional instruments have been effective. Furthermore, the many additions and changes in the manure policy often led to confusion and disbelief among farmers (and policy makers), which further complicated its effectiveness. Yet, the nutrient accounting system MINAS has shown to be an effective policy for decreasing total nutrient losses from dairy farms. Potentially, it could be also an effective instrument for arable farms, but there is no clear evidence yet. MINAS has turned out to be not effective and efficient for pig and poultry farmers.

107. The economic cost for enforcement and administration of MINAS and other instruments have been increasing greatly over the last few years. The high cost for administration is in part caused by fraud,

exploitation of loopholes, juridical procedures, and by the many changes that have been made in the MINAS system and in additional policy instruments. Through these many changes, there has been insufficient time for proper implementation and fine-tuning of MINAS in practice. As such, MINAS has not received yet the credits that it would deserve as instrument to decrease nutrient losses from especially dairy farming, according to the polluter-pays principle.

108. The judgement of the European Court, the increasing administrative burden, increasing fraud, and the absence of environmental benefits in the pig and poultry sectors (where manure surpluses are largest) have led to a very rapid erosion of MINAS. By the end of 2005, MINAS will be replaced by a (complex) fertilization balance approach system with application limits for animal manure and fertilizers, in compliance with the Nitrates Directive. It remains to be seen whether such a system is equally effective and efficient for dairy farms, arable farms and pig and poultry farms.

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

	Population	Employment	Agricultural area,		Cereals	Grassland	Livestock number (millions)			Livestock number		Farm size
Country	million	in Ag., %	% of total	M ha	%	%	Cattle	Dairy	Pigs	ha	holding	ha
Austria	8	7	41	3	25	53	2.1	0.7	3.4	0,82	19	16
Belgium + L*)	11	2	46	2	22	47	3.1	0.6	7.7	3,14	84	21
Denmark	5	4	63	3	56	14	1.9	0.6	11.6	1,59	96	43
Finland	5	7	7	2	52	5	1.1	0.4	1.5	0,59	26	24
France	59	4	52	28	30	35	20.2	4.4	15.9	0,88	48	42
Germany	82	3	48	17	41	30	14.9	4.8	26.1	1,10	48	32
Greece	11	18	27	4	37	57	0.6	0.2	1	0,66	5	4
Ireland	4	11	61	4	7	69	6.6	1.2	1.8	1,60	48	29
Italy	58	6	49	15	24	28	7.2	2.1	8.4	0,72	15	6
Netherlands	16	4	56	2	11	53	4.2	1.7	14	3,85	104	19
Portugal	10	14	41	4	17	26	1.4	0.4	2.4	0,61	7	9
Spain	40	8	51	26	23	35	6.3	1.2	22.4	0,44	27	21
Sweden	9	3	7	3	41	15	1.7	0.4	2.1	0,68	37	35
United Kingdom	60	2	66	16	22	64	11.2	2.5	7	1,02	94	69
EU-15	378	5	40	128	28	37	82.7	21.1	125	0,90	33	18
CC-10	75	13	51	38								4
USA	285	2	40	381								177

Table 2. Changes in some characteristics of agriculture of the Netherlands in the period 1810 to 1950, all expressed in millions

Characteristics, in millions	1810	1850	1880	1910	1920	1930	1940	1950
Surface area agricultural land, ha	1.8	1.9	2.1	2.2	2.2	2.3	2.3	2.3
Surface area natural land, ha	0.9	0.8	0.7	0.5	0.5	0.4	0.4	0.3
Surface area of greenhouses, ha	0	0	0	<0.01	0.01	0.01	0.03	0.03
Milking cows, number	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.4
Pigs, number	0.2	0.2	0.4	1.0	1.5	2.0	1.2	2
Poultry, number	1.5	1.8	2.5	6.7	5.8	12.9	21	11
Horses, number	0.2	0.2	0.3	0.3	0.4	0.3	0.3	0.3
Fertilizer N, kg	0	0	1	15	20	53	103	156
Fertilizer P, kg	0	0	2	24	33	46	47	52
Fertilizer K, kg	0	0	1	27	48	88	111	128

Sources: After Verslagen over den Landbouw in Nederland 1830-1950; Van Zanden (1985); Bieleman (1992) and unpublished data.

Table 3. Changes in some characteristics of agriculture of the Netherlands in the period 1950 to 2000, expressed in millions.

Changes in total energy use and in the use of natural gas by the whole society are given at the bottom of the table. The energy use by the agro-complex is about 12% of the total use.

Characteristics, in millions	1950	1960	1970	1980	1990	2000
Surface area agricultural land, ha	2,3	2,3	2,2	2,1	2,0	2,0
Area of greenhouses, ha	0.003	0.005	0.007	0.01	0.012	0.016
Milking cows, number	1,4	1,6	1,9	2,4	1,9	1,5
Pigs, number	2	2	6	10	14	13
Poultry, number	41	45	55	81	93	105
Horses, number	0.2	0.1	0.05	0.05	0.1	0.2
Tractors, number	0.02	0.08	0.14	0.18	0.18	0.16
Fertilizer N, kg	156	224	396	485	412	340
Fertilizer P, kg	52	49	48	36	33	27
Fertilizer K, kg	128	115	107	93	81	70
Energy use inland economy, PJ	606	925	2014	2732	2702	3024
Use of natural gas, PJ	0	11	635	1274	1290	1467

Sources: Smaling et al., 1999; CBS/LEI, 2000; CBS, 2001.

Table 4. Main types of current farming systems, number of farms, total surface area and mean surface area per farm in The Netherlands in 1999.

Horticulture and Floriculture include greenhouse cultures (between brackets). (CBS/LEI, 2000).

Farming system	Number of farms, thousands	Surface area, in 1000 ha	Average area per farm, ha	Share in total surface area, %
Arable farming	14	485	35	25
Horticulture	5 (3)	25 (7)	5 (2)	1
Floriculture	8 (5)	41 (9)	5 (2)	2
Fruit & tree nursery	5	37	7	2
Dairy & beef farming	49	1100	23	56
Pig farming	7	39	6	2
Poultry farming	2	9	5	0
Mixed farming	10	225	21	11
Other	1	5	4	0
Total	102	1967	19	100

Table 5. Example of a MINAS balance sheet for N of a dairy farming system.

Inputs	Kg/ha/yr	Outputs	Kg/ha/yr
Purchased fertilizer	150	Sold milk	80
Purchased animal feed	200	Sold cattle	10
Purchased manure	0	Transferred animal manure	100
Purchased cattle	10	Sold animal feed	0
Purchased bedding material	20		
Purchased compost	0	Levy-free surplus	180
		Levied surplus	10
TOTAL	380	TOTAL	380

Table 6. Levy-free surpluses for N according to the manure policy, in kg per ha per year.

Land use and soil type	1998	2000	2001	2002	2003
Grassland, dry sandy soils	300	275	250	190	140
Grassland, other soils	300	275	250	220	180
Arable land, dry sandy soils	175	150	125	100	60
Arable land, other soils	175	150	150	150	100

Table 7. Levy-free surpluses for P according to the manure policy, in kg P per ha per year.

Land use	1998	2000	2001	2002	2003
Grassland	17.5	15.3	15.3	10.9	8.7
Arable land	17.5	15.3	15.3	13.1	10.9

There is no differentiation according to soil type. Note that levy-free surpluses are usually expressed in kg P_2O_5 per ha (1 kg P = 2.29 kg P_2O_5).

Table 8. Levy-free N and P surpluses as function of variant, land use and soil type.

Variants	Area of dry sandy soils (ha)	Levy-free N surpluses, kg N/ha/yr		Levy-free P surpluses, kg P/ha/yr	
		Grassland clay soil/dry sandy soils	Arable land clay soil/ other soils/ dry sandy soils	Grassland	Arable land
A	0	300/300	175/175/175	17.5	17.5
B	140.000	220/190	150/110/100	11	13
D1	140.000	180/140	100/100/60	8.7	8.7
H	600.000	140/100	60/60/40	0.4	0.4

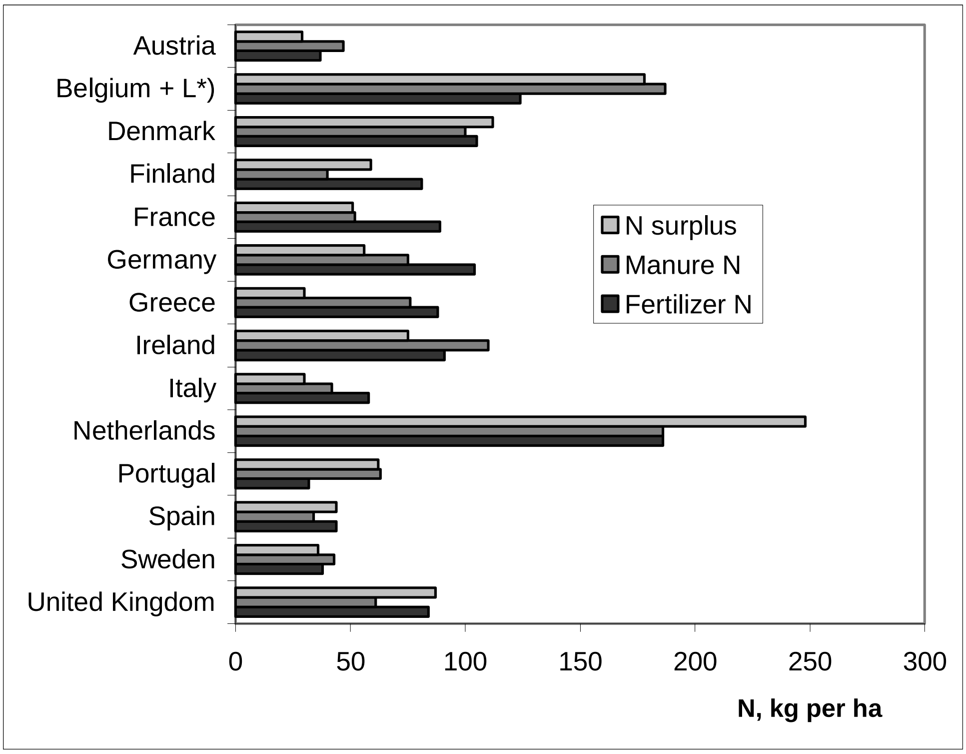
The definition of dry sandy soils differs between variants, and as consequence, the areas too.

Table 9. Calculated effects of implementing different variants of levy-free surpluses (A, B, D1 and H) on the mean net loading of agricultural soil with N and P

Variants	A	B	D1	H
Net Nitrogen loading of the soil, kg N per ha per year	168	133	119	98
Net Phosphorus loading of the soil, kg P per ha per year	15	14	11	2
Emissions of NH_3, kg per ha per year	80	68	64	53
Emissions of N_2O, kg per ha per year	13	11	10	9
Area with > 100 mg NO_3^- per liter in groundwater, %	17	7	4	1
Area with > 50 mg NO_3^- per liter in groundwater, %	33	25	21	14

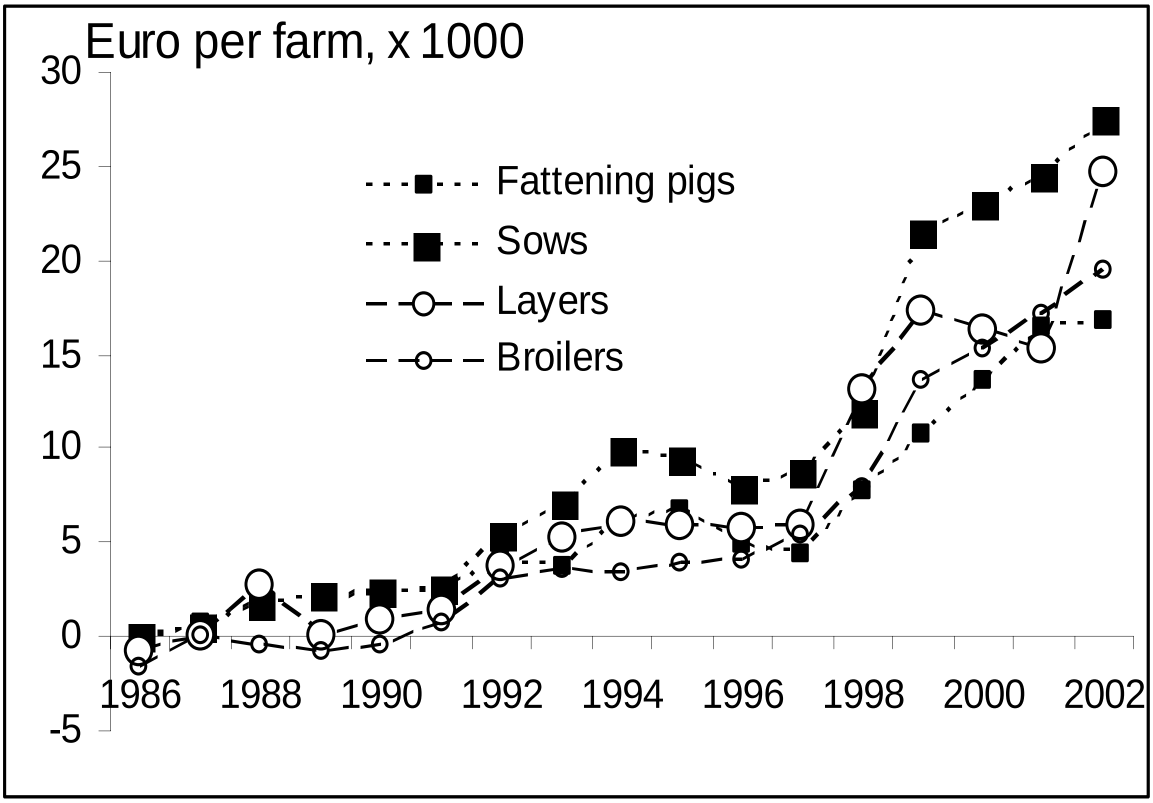
According to the soil surface balance method, emissions of NH_3 and N_2O into the atmosphere, and of area of agricultural land (in percent of the total of 2 million ha) with a nitrate concentration in the upper groundwater that exceeds 50 and 100 mg per liter (RIVM, 2002).

Figure 1. Total net Nitrogen input on agricultural land via fertilizers and animal manure, and total mean Nitrogen surplus in EU-15 in 1997.



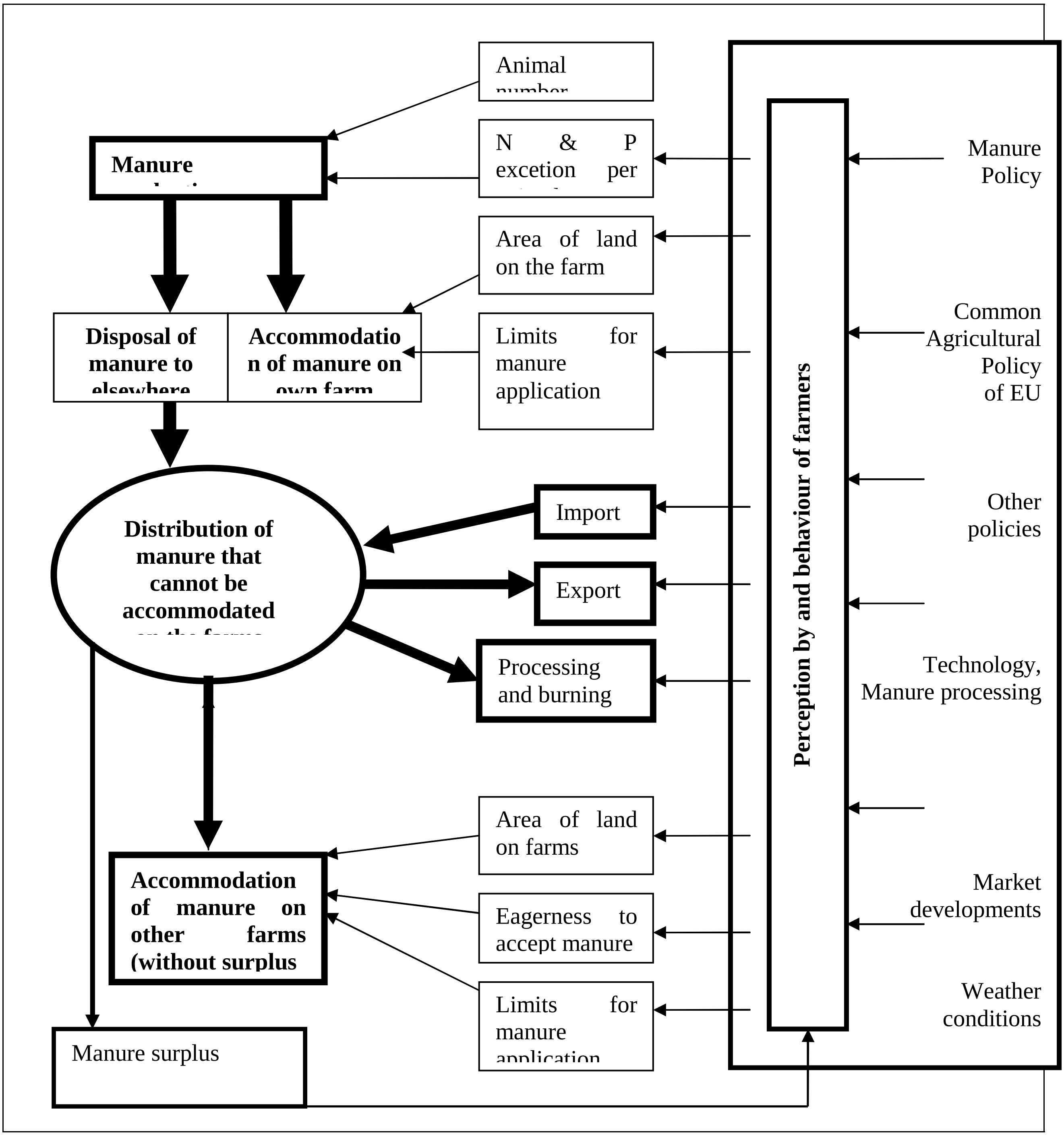
Inputs of N are corrected for ammonia emissions. Belgium + L* is Belgium + Luxembourg. (OECD, 2001; DG-AGRI, 2002; Eurostat, 2002).

Figure 2. Cost of manure disposal per farm for specialized poultry and pig producers in the period 1986-2002



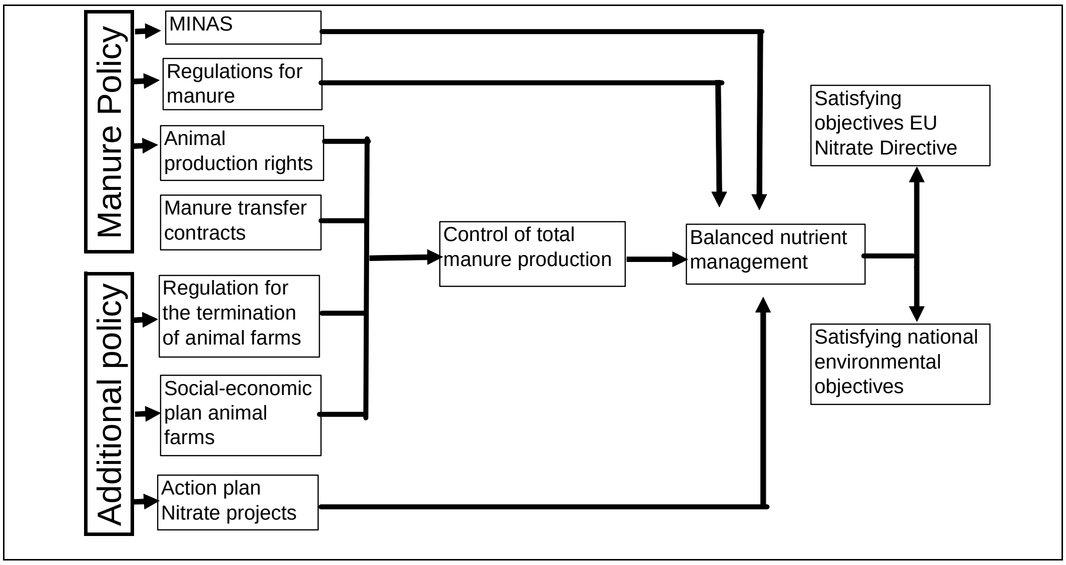
Source: after RIVM, 2004.

Figure 3. Supply and demand of animal manure on the manure market.



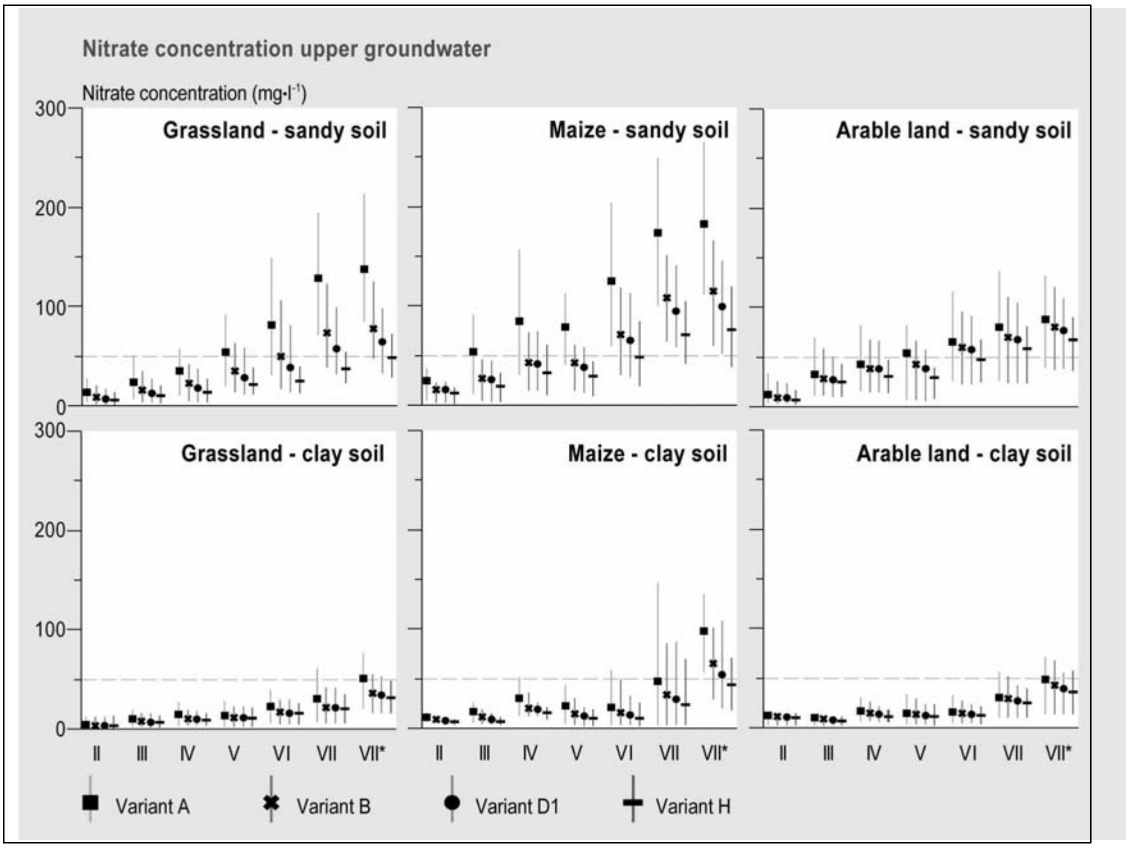
Farm external factors influencing supply and demand are listed at the right-hand side of the figure. Farm internal factors influencing manure production and manure disposal are listed in the centre. The upper half of the figure shows the factors influencing manure production and manure disposal on farms where manure is produced. The lower half shows the factors influencing accommodation of manure from elsewhere. Thin arrows indicate influences of factors; thick arrows indicate flows of animal manure.

Figure 4. Schematic representations of the connections between the current instruments of the Manure Act and the current instruments of the Additional policy.



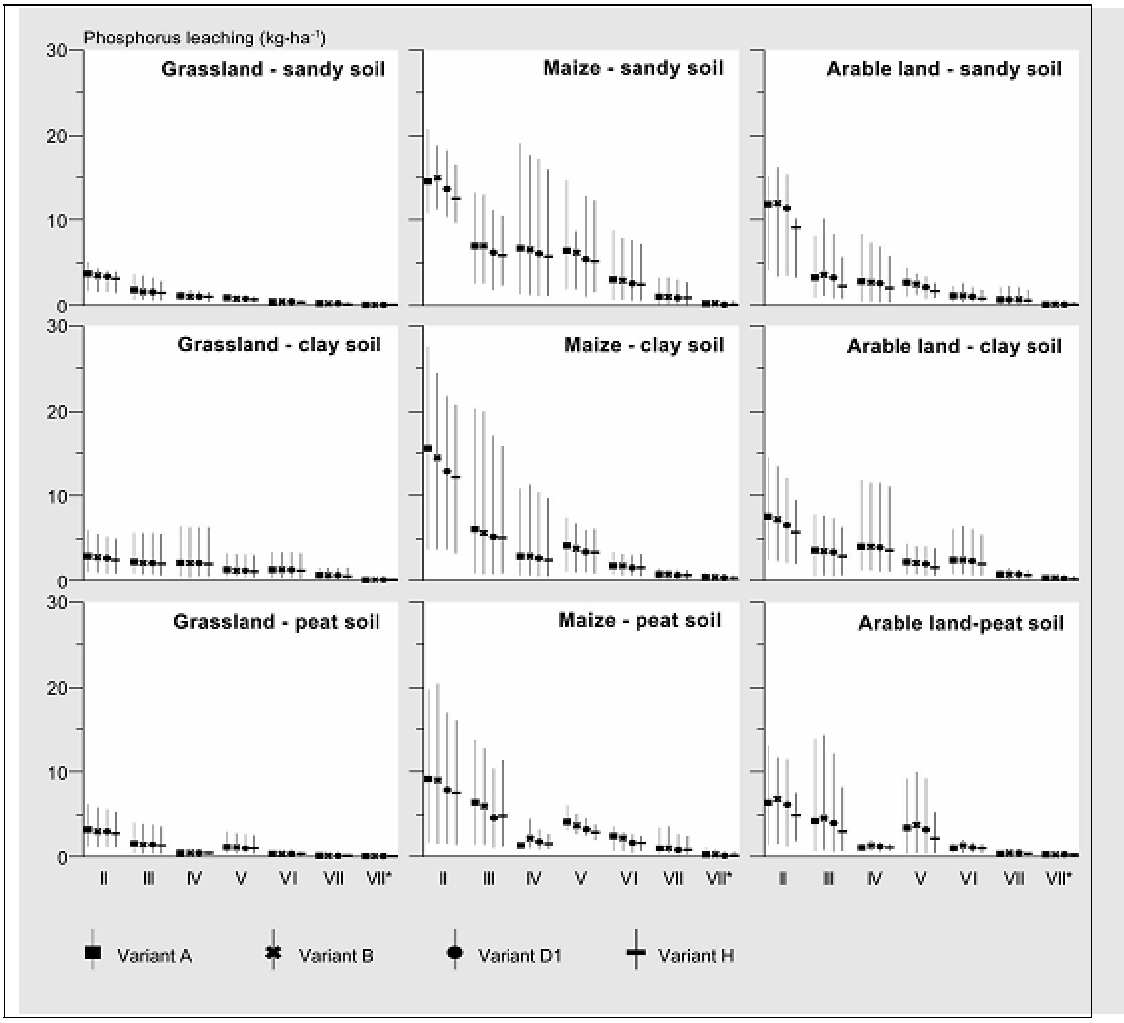
Source: After RIVM, 2004.

Figure 5. Calculated nitrate concentrations in the upper groundwater



Averaged over 15 years, as function of groundwater class (x-axis), land use (grassland, maize land and arable land), soil type (sand versus clay), and variant (A, B, D1 and H). Concentrations are presented as means (dots) and 5 and 95 percentiles (bars). Groundwater class reflects the mean upper (in winter season) and mean lower (in summer) groundwater level. For class I upper and lower groundwater levels are <20 cm, for class VII* upper and lower groundwater level are >120 cm. Note that surface areas differ between groundwater classes, from 48.000 ha for class I to 770.000 ha for class VI (after Oenema et al., 2004a).

Figure 6. Calculated phosphorus leaching to surface waters,



Averaged over 15 years, as function of groundwater class (x-axis), land use (grassland, maize land and arable land), soil type (sand, versus clay and peat), and variant (A, B, D1 and H). Total leaching losses are presented as means (dots) and 5 and 95 percentiles (bars). Groundwater class reflects the mean upper (in winter season) and mean lower (in summer) groundwater level: for class I upper and lower groundwater levels are both <20 cm, for class VII* upper and lower groundwater level are both >120 cm. Note that surface areas differ between groundwater classes, from 48.000 ha for class I to 770.000 ha for class VI (after Oenema et al., 2004a).

ANNEX 1. ENVIRONMENTAL EFFECTS OF LOWERING NITROGEN AND PHOSPHOROUS SURPLUSES[2]

This annex presents the results of model calculations of four variants of different combinations of levy-free surpluses. The results are expressed in terms of nitrate leaching to groundwater, ammonia and nitrous oxide volatilization to the atmosphere and N and P leaching to surface waters. Levy-free surpluses for N and P differ for grassland and arable land, and for different soil types. They decrease from variant A, to B to D1 and are lowest for H (Table 8). The calculations have been made to explore the effects of possible combinations of levy-free surpluses on environmental quality, and to analyze the spatial variations in effects.

Lowering levy-free N and P surpluses, i.e. implementing variants A, B, D1 and H decreases the net loading of agricultural soil with N and P (Table 9). Differences in net loading of the soil between variants A and H were almost a factor 2 for N and a factor 7 for P. These differences indicate that changes in levy-free N and P surpluses could be effective in decreasing the net loading of the soil with N and P. Note that numbers in Table 8 indicate calculated means for all agricultural land; differences between areas in net loading of the soil with N were up to a factor of 2, because of differences in land use and because of differences between land use systems and soil types in levy-free N surpluses.

Lowering levy-free N and P surpluses decreases the mean emissions of NH_3 and N_2O to the atmosphere also significantly (Table 9), but relative decreases are less than the decreases in net loading of the soil in N.

Nitrate concentrations in the upper groundwater are related to the net N loading of the soil, soil type, land use system and groundwater level. Concentrations are low when groundwater level is shallow, because of denitrification and leaching to surface waters. At a similar net N loading of the soil, concentrations are lower for grassland than for arable land, because of differences in denitrification and a difference balance between immobilization and mineralization of N in soil. Lowering levy-free N and P surpluses decreases the concentrations of nitrate in the upper groundwater (Figure 5). Decreases are most significant for dry sandy soils, vulnerable to nitrate leaching; nitrate concentrations decrease from a mean of 100-200 mg per liter for variant A to a mean of 50-100 mg per litre for variant H (Figure 5). Mean concentrations in sandy soils appear higher for maize land than for grassland, though levy-free N surpluses are lower for maize land than for grassland. Relatively high nitrate concentrations in maize land have been ascribed to residual effects of heavy manure applications in the past. Mean concentrations in sandy soils appear somewhat lower for arable land than for grassland, mainly because of lower levy-free N surpluses, especially in variant A. Nitrate concentrations in the upper groundwater of peat soils are negligible low (not presented).

The spatial variability and the variability between years are large. Related to the large spatial variability, there are still significant areas of agricultural land where the nitrate concentrations in the upper groundwater exceed the level of 50 mg per litre. The area of agricultural land with more than 50 mg nitrate per liter decreases from 33% to 14% (i.e. with about 400.000 ha) when lowering levy-free N surpluses from variant A to H (Table 8). The relative decrease of the area with more than 100 mg nitrate per litre in

[2] After Oenema et al., 2004a.

the upper groundwater is large, from 17% to (less than) 1%. Sandy soils with relatively deep groundwater level (>120 cm below surface; i.e. groundwater class VII*, and VII) in the southern and eastern half of the country appear most vulnerable for nitrate leaching. It has been suggested that low levy-free N surpluses in combination with additional measures, such as cover crops in winter and restricted grazing, are needed to lower nitrate concentrations in the upper groundwater of dry sandy soils to below 50 mg per liter (RIVM, 2002).

Leaching of N and P to surface waters is related to the net loading of the soil with N and P, hydrology (groundwater class and drainage), and to a lesser extent to land use and soil type. The most dominant factor is hydrology. Total leaching losses are the resultant of the water discharge (drainage, overland flow, and subsurface seepage) to surface waters and the concentration of N and P in the discharge, which are both but in different ways related to groundwater class. For groundwater class II, total discharge to surface waters and P concentration in the discharge are relatively high, but N concentration relatively low (because of denitrification losses). In contrast, groundwater recharge is large and discharge to surface water is low in soils with groundwater class VII*. The soils with groundwater class VII* also have low P concentration in the discharge, because of strong adsorption to iron (oxy)hydroxides, and high N concentration, because of little N loss through denitrification. These complex interactions indicate that total leaching of N and P to surface waters decrease exponentially with increasing groundwater class, i.e. from class I to class VII*, and that spatial and annual variability are large.

Lowering the levy-free N and P surpluses (from variant A to variant H) decreases the leaching of N and P to surface waters with 25% and 15%, respectively. The relative decreases are less than the relative decreases in mean levy-free N and P surpluses and in mean net loading of the soil with N and P (Table 9). This apparent ineffectiveness of decreasing leaching of N and P to surface waters by lowering levy-free N and P surpluses at farm level has been attributed to:

1. Spatial effects: the discharge of excess rain water to surface water is largest in the northern and western half of the country, where the decrease in net loading of the soil is less than in the southern and eastern half (because of differences in land use and farming practices);
2. Contribution of background leaching: nutrient-rich seepage from the marine and riverine subsoil is 30 to 40% of the total leaching losses from soils to surface waters, and this seepage is assumed to be invariable of variant; and
3. P leaching is primarily related to the P saturation index of the soil, which is also nearly invariable of variant in the short term considered here (but not in the long term).

Lowering levy-free N surpluses from variant A to variant H decreases mean N leaching to surface waters with 10 to 25 kg per ha per year for the wet soils with groundwater classes I to III. For the dominant groundwater classes VI and VII, decreases for N are in the range of 1 to 10 kg per ha per year, and that for P in the range of 0-2 kg per ha per year. The spatial variability in P leaching is large, and primarily related to the large spatial variations in groundwater class and P saturation index. Variations between years are also extremely large (up to factor 3), because of incidental P losses (Box 2).

Lowering the levy-free N and P surpluses from variant A to variant H has negligible effects on N and P concentrations of the rivers Rhine and Meuse in The Netherlands, and of the largest lake IJsselmeer. Concentrations of N and P in IJsselmeer range from 2 to 3 and from 0.13 to 0.18 mg per liter, respectively, and are independent of variant. Lowering the levy-free N and P surpluses from variant A to variant H decreases N and P concentrations of ditches and streams by about 20%. This decrease is insufficient to decrease the coverage of ditches by duckweed significantly. Approximately 80% of the ditches (total length approximately 600.000 km) in The Netherlands have duckweed coverage. This coverage is related to the P concentrations; when P concentrations are 0.3 or higher, duckweed coverage is 100% (Van Liere and Jonkers, 2002). In the short term, decreasing the levy-free P surpluses appears to be a relatively ineffective policy for decreasing P concentrations in surface waters. For the long term however, decreasing levy-free P surpluses is a prerequisite. A combination of low levy-free surpluses in agriculture and additional measures (dredging of P-rich sediment, flushing) is needed for full ecological restoration of inland surface waters

Nutrient concentrations in the Dutch coastal waters are strongly influenced by riverine inputs (predominantly the river Rhine), whereas concentrations offshore are determined by Atlantic water. Lowering the levy-free N and P surpluses from variant A to variant H has small effects (<5%) on N and P concentrations of coastal waters. Basically, this is because of the dominant influence of the rivers Rhine, Meuse and Scheldt on nutrient concentrations in the coastal waters.