The Mineral Accounting System: Analysis of environmental and economic performance of 240 farms in The Netherlands

PAPER FOR THE ISEE MEETING 'PEOPLE AND NATURE: OPERATIONALISING ECOLOGICAL ECONOMICS', 5-8 JULY, 2000 CANBERRA AUSTRALIA

Christien J.M. Ondersteijn[1,2], Gerard W.J. Giesen[1], Ruud B.M. Huirne[1]

[1]Department of Social Sciences, Farm Management Group, Wageningen University
[2]Agricultural Economics Research Institute

Abstract:
The last decades, surface and groundwater across Europe, which is partly meant for human consumption, is being polluted by nutrient run-off and leaching from agricultural sources. To contain this pollution, the European Union issued the Nitrate Directive (91/676/EEC) to establish a safety standard of 50 mg of nitrate per litre of groundwater. In response to this, the Netherlands implemented the Mineral Accounting System (MINAS), which focuses on nutrient flows (nitrate and phosphate) on individual farms, and taxes farms whose nutrient surplus exceeds a defined limit, known as the Levy Free Surplus (LFS). LFS will gradually be reduced, until the safety standard is met in 2008. To investigate the feasibility of the LFS, and the impact of MINAS on farm performance, detailed panel data of 240 farms from a stratified sample were collected from 1997 through 1999. This paper describes and analyses the results of 1998, the first year MINAS was operational. MINAS-surpluses differed dramatically between farm types, ranging from 64 kg N/ha for arable farms up till 299 kg N/ha for mixed dairy and livestock farms. Within farm type analysis showed even larger differences in surplus ranges; up to 421 kg N/ha for dairy farmers. Still, in 1998, 70% of the farms did not exceed the LFS and both intensive and extensive farms were able to meet the standards. Unchanged nutrient management will, however, lead to average levies as high as 266 €/ha for 81% of the farms in 2008. At the individual farm level, this can seriously threaten viable economic performance.

1. Introduction

In the past decade it has repeatedly been shown that agriculture is a significant source of ground- and surface water pollution (e.g. Carpenter et al., 1998, Heathwaite et al., 1996). Consequences are possible health hazards like the 'blue baby syndrome' and stomach cancer, which are associated with an overexposure to nitrogen (Harrison, 1995), and neurological damage which has recently been associated with toxic chemicals produced by a dinoflagellate, which is able to bloom because of excessive phosphates (Carpenter et al., 1998). Probabilities of occurrence of these hazards are low since drinking water is cleansed thoroughly (Griffith, 1999). However, costs of drinking water purification are high and will increase in the future, if nutrient levels do not decrease. Another urgent problem associated with nutrient pollution by agriculture is eutrophication of surface and marine waters, which has many negative effects on aquatic ecosystems, like explosive algae growth (Carpenter et al., 1998).

The problems accompanying leaching of nutrients through agriculture has led to a variety of policy measures especially in Europe ranging from strict regulations to voluntary adaptation of financially attractive management practices by farmers. The European Community initially focussed its' efforts mainly on water for human consumption (Goodchild, 1998). Recent developments however, have led the EC to shift efforts towards the environmental effects of excess nutrients, particularly nitrogen. This resulted in several directives of which one has direct impact on agriculture: Council Directive 91/676/EEC, also called The Nitrate Directive. The Nitrate Directive concerns the protection of waters against pollution caused by nitrates from agricultural sources (EEC, 1991). The Directive provides guidelines for implementation of provisions to reduce and prevent water pollution caused or induced by nitrates from agriculture (Frederiksen, 1994).

Dutch agriculture is one of the most intensive ones in the world in terms of capital and external nutrient inputs (van Bruchem et al., 1999). Furthermore, rapid intensification of livestock production, a result of the focus on increasing productivity from the 50's on, has contributed to a large increase in nutrient surpluses (Oenema et al., 1998). Dutch policy concerning agricultural pollution stems from the mid 80's when the Manure and Fertiliser Act and the Soil Protection Act were introduced (de Walle en Sevenster, 1998). Most recently, the Mineral Accounting System (MINAS) was introduced to ensure compliance with the Nitrate Directive. From 1998 onward the system applied to livestock farms with a density higher than 2.5 LU/ha.

Later on the system will be extended to cover all farms, including crop farms. Simulation studies have shown that MINAS will reduce nitrogen and phosphorus losses by 58 and 82% respectively (Oenema and Roest, 1998). This will result in a decrease in nitrogen leaching by 38%. Phosphate leaching was not expected to decrease. The study by Oenema and Roest assumed however, that farmers do not exceed the levy free surpluses. Research on the experimental dairy farm De Marke shows that efficient nutrient management to meet the MINAS standards, requires numerous changes in management practices (Aarts et al., 1992; Aarts et al., 1994).

This paper aims to show how 'real-life' farmers cope with MINAS and nutrient management and how farmers can focus their efforts in order to meet the standards and thus reduce groundwater contamination. First, the implementation of the Nitrate Directive in The Netherlands is explained, including the latest modifications. Second, farm results of 240 farms, covering 5 farm types, spread over The Netherlands are analysed showing large variety in performance between but also within farm types. Finally the consequences of these results in terms of MINAS are shown.

2. The European Nitrate Directive versus MINAS

Council Directive 91/676/EEC of December 12, 1991 concerns the protection of water against pollution caused by nitrates from agricultural sources (EEC, 1991). The main goal is to ensure nitrate safety of European drinking water through upholding a maximum level of 50 mg nitrate (NO_3) or 11.3 mg nitrogen (N) per litre of groundwater. It is better known as the Nitrate Directive and it states that member states must monitor all waters and identify zones vulnerable to nitrate leaching. They have to establish a Code of Good Agricultural Practice, to be implemented voluntarily, and finally, an Action Program concerning the vulnerable zones must be formulated and contain restrictions on manure application (Frederiksen, 1994). Vulnerable zones are defined as areas where agricultural production contributes to drinking water quality problems. The Netherlands have been monitoring their waters for years and designated the whole territory as being a vulnerable zone. The reason for this is that groundwater in The Netherlands provides roughly two-thirds of the drinking water supplies. Recently, at a small number of extraction points nitrate concentrations of aquifers have exceeded the value of 50 mg per litre and this number is increasing (de Walle en Sevenster, 1998). Furthermore, increasing eutrophication of marine and surface waters justified designation of the whole Dutch territory as a vulnerable zone. A code of Good Agricultural Practice was established, mostly based on previously existing measures and an Action Program was submitted.

In order to meet the requirements of the Directive and to maintain an economically healthy agricultural sector, the Dutch government designed a nutrient accounting system, based on loss standards for both nitrogen and phosphates, instead of application standards for nitrogen. The Nitrate Directive focuses solely on nitrogen. The Netherlands decided to incorporate phosphate in their system as well. The reason to integrate phosphate into the system is due to the soil conditions in the Netherlands. Phosphate leaching is generally not very likely but can vary with soil type and soil conditions. Sandy soils are more prone to phosphate leaching than other soil types, especially when saturated. The south and south-east part of The Netherlands are predominantly sandy. On top of that, most of the intensive farming systems are located there, which results in saturated soils due to the excessive use of animal manure. To cope with this, the nutrient accounting system, called MINAS, uses a so-called 'farm gate balance approach' (Brouwer and Kleinhanss, 1997; van den Brandt, 1998). Only nitrogen and phosphate entering (input) and leaving (output) the farm through the farm gate is taken into account while the farm itself is considered a black box. Concentrates, roughage, by-products, manure, animals and chemical fertilisers that 'enter the gate' are considered inputs, while milk, animals, eggs, wool, roughage, arable products, vegetables and animal manure that leave the gate are considered outputs. Furthermore, ammonia losses from stables are taken into account as a fixed loss per animal. The difference between inputs and outputs is the farm surplus. Figure 1 graphically explains the MINAS system. Note that MINAS does not take into account plant material yet. The difference between the farm surplus and the levy free surplus is taxed with a levy. MINAS is to be implemented in stages, starting in 1998 for farms with more than 2.5 LU/ha. Gradually all farms, including arable farms will be introduced to the system, furthermore, loss standards will gradually be reduced until the safety standard of 50 mg of nitrate per litre is met. The ultimate goal of Dutch nutrient policy is to reach balanced fertilisation. In order to achieve this, the manure market has to be balanced as well. The Dutch government proposed a restructuring of the intensive livestock production sector to withdraw 14 million kilogram of phosphate from the market in an effort to force the market into balance.

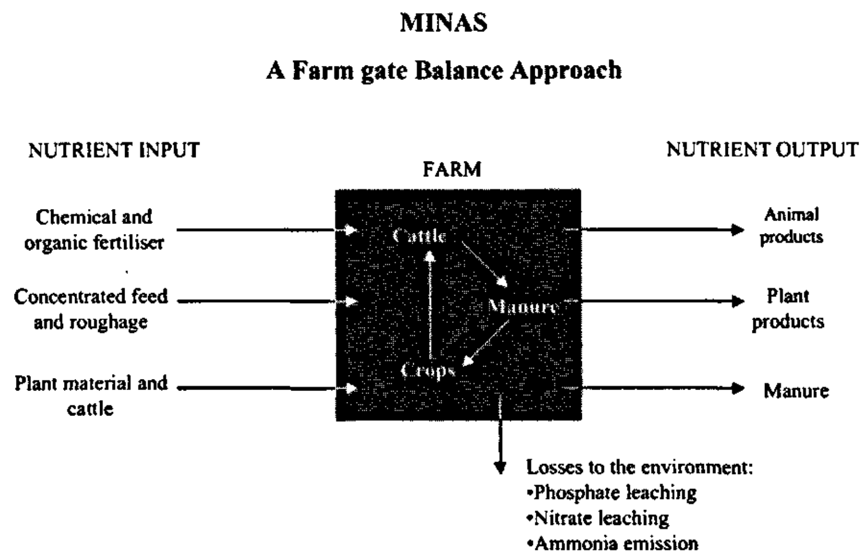


Figure 1. The MINAS system, considering the farm a black box

MINAS embodies a new approach to environmental problems caused by agriculture. This new approach focuses on the individual farmer and his management, because studies have shown that diversity among adequate measures to reach balanced fertilisation is high among farms. Comparative studies have also shown that intensive livestock farms do not necessarily produce higher surpluses than extensive livestock farms, when quality of nutrient management on the farm is high. Nutrient management is therefore considered more important than farm characteristics like livestock density (Van den Brandt and Smit, 1998). Several studies have shown that the final standards for acceptable surpluses will lead towards the desired 50 mg of nitrate per litre of groundwater (see e.g. Oenema et al., 1998). The results of their simulation model showed that, given the fact that farmers will meet the final standards, average nitrogen surplus at farm level will decrease to a mean of 147 kg/ha which, in turn will lead to a 60% decrease in nitrate concentrations of the average lowest groundwater level. Only 12% of agricultural land (dry and medium dry sandy soils) will need additional regulations to achieve the same objective.

The Netherlands did not manage to comply with the Directive in a timely manner nor did it manage to completely address all components of the action program, especially that of land application of livestock manure. Manure application is, according to the Directive, to be limited to 210 kg N per ha per year from 1998 up to 2002 and to 170 kg N per ha per year from 2002 on. One LU produces approximately 140 kg N in manure per year. This means that livestock density has to be reduced to 1.5 LU/ha up till 2002 and little over 1 afterwards. Considering that in The Netherlands, average dairy-livestock density was as high as 1.9 in 1998 (CBS, 1999), this will lead to drastic cutbacks in cattle, and, as a result, of farmers. The critique of the European Committee of the Dutch implementation of the Directive consisted of three components. First, it did not sufficiently address the application of manure, second, goals would be effectuated too late (2008/2010) and third, the levies were insufficient to reduce nutrient losses. March 1, 2000, the Committee decided to take The Netherlands to the European Court (Brinkhorst, 2000).

The Dutch government responded to these critiques with a proposal for application standards for manure (Brinkhorst and Pronk, 1999). These standards exceed the ones stated by the EC by 80 kg of N in 2003 for grassland (250 kg N instead of 170) and level with the EC standards for arable land (170 kg N). The Dutch government plans to use the option of derogation for grassland, arguing that a long growing seasons with high nitrogen uptake ensures meeting safe drinking water standards (Willems et al., 2000). Furthermore, the final levy free surpluses (LFS) are shifted from 2008 towards 2003 in order to reach a balanced fertilisation in time, and a system of 'manure contracts' will be introduced in which farmers who have excess manure (based on standard production per animal and application possibilities on his own farm) must have a contract with a farmer who has excess application space on his farm to ensure that manure production does not exceed application possibilities in The Netherlands as a whole. Table 1 shows the new surplus and application standards to be implemented in 2002. Standards that are currently in use will be applicable untill 2002. Changes, including the introduction of application standards are scheduled to become effective in 2002.

Table 1. Overview of levy free surpluses for different stages to reach the final standards in 2003 (Brinkhorst en Pronk, 1999)

	1998-1999	2000-2001	2002	2003*
Levy free surpluses (kg N/ha or kg P_2O_5/ha)				
Grassland				
N surplus	300	250	190	180
P_2O_5 surplus	40	35	25	20
Arable land				
N surplus	175	125	100	100
P_2O_5 surplus	40	35	25	20
Application standards (kg N/ha)				
Grassland			300	250
Arable land, excl. fodder maize land			170	170
Fodder maize land			210	170

* Extra measures are announced for sandy soils vulnerable to leaching (levy free surplus 140 kg N on grassland and 60 kg N on arable land). Locations of sandy soils have not yet been designated however.

While LFS are decreased in 2002, levies itself are increased. One kilogram of excess nitrogen is currently taxed with € 0.68. Starting 2002 this will rise up to € 2.27. Excess phosphate will be taxed even heavier. The first 10 kg of excess phosphate are currently taxed with € 2.27, every other kg with € 9.08. The levy on phosphate will be equalised in 2002 to € 9.08 for every excess kilogram of phosphate. The reason for these increases is to make it less (or not at all) attractive for farmers to find and 'optimal' nutrient surplus, where the marginal costs of the levy is equal to the marginal return of extra output. In order for the government to reach the desired levy free surpluses, and thus a balanced fertilisation, farmers should not be tempted to allow a certain 'optimal' excess.

3. Farm results of the FDP participants

Sample Selection

As noted in paragraph 2, research has shown that *if* farmers would meet the levy free surpluses, the maximum nitrate content of groundwater as directed by the European Committee would be met (Oenema et al., 1998). A discussion between policy makers and farm organisations on the feasibility of the surplus standards initiated a project called Farm Data in Practice (FDP, 'Project Praktijkcijfers'). Research indicated that improvements in performance and nutrient budgets could be made by improving tactical and operational management (e.g. Van der Meer and Van der Putten, 1995). About 240 participants in the 3-year (1997-1999) FDP project were supposed to focus on tactical and operational management and thus show what is possible in terms of nutrient surpluses. The main goal was knowledge development and transfer to colleagues. Five farm types, namely specialised dairy farms, mixed dairy and intensive livestock farms, mixed dairy and arable farms, specialised arable farms, and mixed arable and intensive livestock farms, all land based, were studied in the FDP project.

Farms in the FDP project were selected out of a voluntary enrolment, to meet a predetermined stratification that represents the spread of farm types and soil types over The Netherlands. Furthermore, phosphate conditions of the soil had to be sufficient (An., 1996). A bias with regards to the reason for participation was likely to exist since the project was heavily loaded with political interest. A short survey at the start of the project showed that the most important reason for farmers to participate was the fact that it would benefit themselves and their farm because of the knowledge transfer involved (average score was 4.5 on a scale of 1 to 5). Showing policy makers that standards are not feasible and showing colleagues that low surpluses are feasible scored averages of 3.7 and 3.6 (3 was considered neutral) respectively. More than half (57%) of the participants said to have joined the project to show that standards are not feasible. This does not necessarily mean that these participants were also intended on frustrating the project but the number needs to be taken into consideration when looking at results. Not all participants are aiming for the lowest surplus possible, but the surplus they consider possible on their farm. Only 11% scored below 3 on 'showing that lower surpluses are possible'. This indicates that most were interested in attaining low nutrient results. Figure 2 shows the number and spread of the different farm types over The Netherlands of the 227 farms used in this analysis (227 out of 240 had complete accounting records).

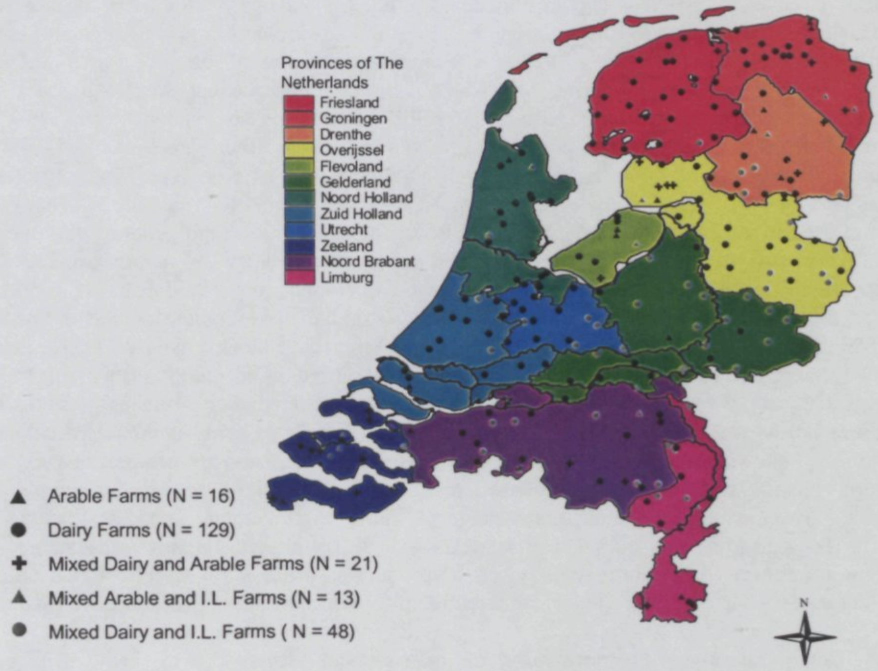


Figure 2. Number and spread of the farm types

Nutrient Results and Farm Sustainability

Because of the stepwise introduction of MINAS, it is possible for farmers to build up stock untaxed before they have to partake in the system. This will cause input and output of nutrients to differ from use and production. In time, use and production will converge with input and output but in the introduction period they may well show large differences. We therefore calculated a 'management surplus', which does take into account stock and therefore gives a more accurate representation of actual nutrient management than does the MINAS surplus which is based on inputs and outputs. Table 2 shows MINAS as well as management surpluses for nitrogen and phosphate per ha for different farm types in the project. Furthermore, gross margin per 100 litres fat and protein corrected milk for (mixed) dairy farms and gross margins per ha for (mixed) arable farms, show financial results.

Table 2. Average (standard deviation) and ranges of nutrient surpluses and gross margins of 1998

	Dairy	Mixed dairy and intensive livestock	Mixed dairy and arable	Arable	Mixed arable and intensive livestock
Nitrogen					
MINAS surplus per ha	268 (78)	299 (86)	238 (74)	64 (82)	202 (100)
Range (min.-max.)	-9 – 505	128 – 586	120 - 380	-44 - 216	54 – 406
Management surplus per ha	258 (78)	281 (71)	242 (71)	126 (75)	240 (119)
Range (min.-max.)	76 – 497	157 – 441	119 - 390	31 - 296	100 – 439
Phosphate					
MINAS surplus per ha	45 (23)	52 (25)	40 (23)	17 (39)	27 (58)
Range (min.-max.)	-15 – 121	-8 – 110	1 - 89	-62 - 87	-143 – 73
Management surplus per ha	40 (23)	39 (25)	44 (27)	42 (37)	64 (54)
Range (min.-max.)	-5 – 113	-21 – 96	4 - 94	-32 - 104	-2 – 207
EURO €					
Gross margin per 100l. fpcm	29 (3)	30 (5)	37 (12)		
Gross margin per ha				1439 (833)	2835 (1817)
Range (min.-max.)	20 - 40	20 - 50	25 - 66	65 - 3281	289 – 6765

Table 2 shows large differences both between (averages) and within farm types (standard deviations and ranges) for nutrient surpluses and financial results. Between farm types, the order of highest through lowest nitrogen surpluses is equal for MINAS and management surpluses. The reason for differences between MINAS and management surplus and farm types can be found in [1]stock changes of roughage and manure for the dairy farms and mixed dairy and intensive livestock farms and [2]standard versus real output of arable and mixed arable and intensive livestock farms. MINAS does not take into account changes in stock so all roughage and manure which is produced in one year but will be used in the next is considered a loss. The management surplus does take the changes into account and surpluses are therefore lower. MINAS uses standards for crop output (165 kg N/ha and 65 kg P_2O_5/ha), regardless of crop type. The management surplus uses samples of crop, which shows that real nutrient output is less than standards. This causes management surpluses to be higher than MINAS surpluses for both arable and arable with intensive livestock farms. Apparently these two effects are averaged out for mixed dairy and arable farms. It is not within the scope of this paper to show detailed information on input, output and use and production (appendix 1 gives a short graphic overview). The same can be said for phosphate although the order of lowest through highest is distorted because of very large difference in stock changes. These extreme differences show the impact of stock changes and standard or real output on nutrient management. In order to account for this distortion we will use the management surplus in the remainder of this paper as the basis for our calculations unless it is useful to do so otherwise. Within farm type analysis (standard deviations and ranges in table 2) shows that differences between farms within the same farm type are very large. Standard deviations are similar for MINAS and management surplus, the minimum and maximum surplus differs between the two, resulting in a different range. A more narrow range suggests that use and production varies less than input and output, which means that decisions with regards to acquiring input and selling output are not only based on necessity for the production process but are also based on other considerations like process and the possibility of stock build up for concentrates and chemical fertiliser.

MINAS forces Dutch farms to integrate nutrient management decisions in their management considerations. This turns their optimisation problem from a mostly monetary problem into a sustainability problem and we can therefore define sustainable nutrient management as decision-making to attain balanced fertilisation while ensuring financial viability. With regards to table 2 we can say that farms with high gross margins and low nutrient surpluses are more sustainable while the least sustainable farms being those with low gross margins and high nutrient surpluses. Table 2 shows that large differences between and within the financial results of the farm types exist. A correlation analysis within farm types showed the relationship between nutrient surpluses and financial results. Significant relationships were identified between the nitrogen surplus and the gross margins for specialised dairy farms and mixed dairy and arable farms (α=0.01). The relationships were negative, indicating that low nitrogen surpluses per ha and high gross margins go hand in hand. These results are in accordance with the definition of sustainable nutrient management. A significant positive relationship was found for mixed arable and intensive livestock farms (α=0.05), meaning that the relationship is not sustainable. These calculations do not include MINAS levies which will lower gross margin significantly as we shall see in section 4. We will use the results found here as a point of departure for further investigations into the relationship between financial and nutrient results.

Nutrient Efficiency and Nutrient Surplus

Low nutrient surpluses per ha do not necessarily mean little waste of resources, or in other words, efficient nutrient management. This is shown in equations 1 and 2.

$$\boldsymbol{Surplus / ha = use / ha - production / ha} \qquad (1)$$

$$\boldsymbol{Surplus / ha = use / ha - \frac{production}{use} \times use / ha} \qquad (2)$$

Equation 1 shows that the management surplus per ha is the difference between use per ha and production per ha. Equation 1 can be transformed into equation 2, which means that the surplus per ha is the result of the use per ha minus the efficiency of the use per ha. Use per ha is largely defined by the farm layout. An extensive farming system will have a low use per ha. If this use is not efficiently managed (ratio of production and use is small), the resulting surplus can still be high. Table 3 shows the efficiency measure for the different farm types (negative production was considered as use to avoid negative efficiency measures). The efficiency measure also contains manure production. One could argue that manure is a waste product and should therefore not be considered an output. On the other hand, due to the pressure of policy measures, manure is nowadays re-evaluated as being a valuable source of nutrients to farm production even though there is a negative price associated with selling manure. As such it should be considered a product. The consequence of this is that efficiency will increase as animal density is higher due to more manure production.

Table 3. Average (standard deviation) and ranges of nutrient efficiency of 1998

	Dairy	Mixed dairy and intensive livestock	Mixed dairy and arable	Arable	Mixed arable and intensive livestock
Nitrogen					
Ratio production/use	35 (11)	51 (14)	40 (13)	48 (16)	65 (14)
Range (min.-max.)	16 – 69	25 - 83	23 - 75	20 - 74	35 – 84
Phosphate					
Ratio production/use	59 (19)	74 (18)	61 (20)	53 (22)	75 (19)
Range (min.-max.)	26 – 107	35 - 105	29 - 98	26 - 91	28 – 102

Table 3 shows that standard deviations and ranges are large for all farm types, indicating a large variety in both N- and P_2O_5-efficiency. It also shows that of the amount of nutrients used, little returns in production. N-efficiency is smaller than P_2O_5-efficiency due to several reasons, which all have to do with the N-cycle (Rauschkolb and Hornsby, 1994). Ammonia volatilisation, immobilisation, denitrification and leaching all cause leaks in the N-cycle. This causes the maximum possible N-efficiency to be within 70% and 90% depending on multiple factors (Miller and Donahue, 1995). Since these processes do not occur in the P-cycle, efficiencies of 100% are possible when no leaching occurs. Efficiencies above 100% indicate exhaustion of soil phosphates.

Efficiency is a typical result of good management and craftsmanship. Providing plant or animal at the right time with the right amount of fertiliser or food will result in little waste and high efficiency. This will also result in low nutrient surpluses since wastes are reduced. The relationship between efficiency and surplus is therefore clear: If farms with high nutrient surpluses also show high efficiencies, there is hardly any room for finding a solution to a high surplus at the management level. On the other hand, when farms with high surpluses show low efficiencies, they may relatively easy be able to reduce surpluses. Relatively easy means that more accurate management with regards to timing of fertilisation and fertilising and feeding based on the needs of plant and animal will lead towards lower nutrient surpluses. Figure 3 shows the current (1998) relationship between surplus and efficiency for both nitrogen and phosphate.

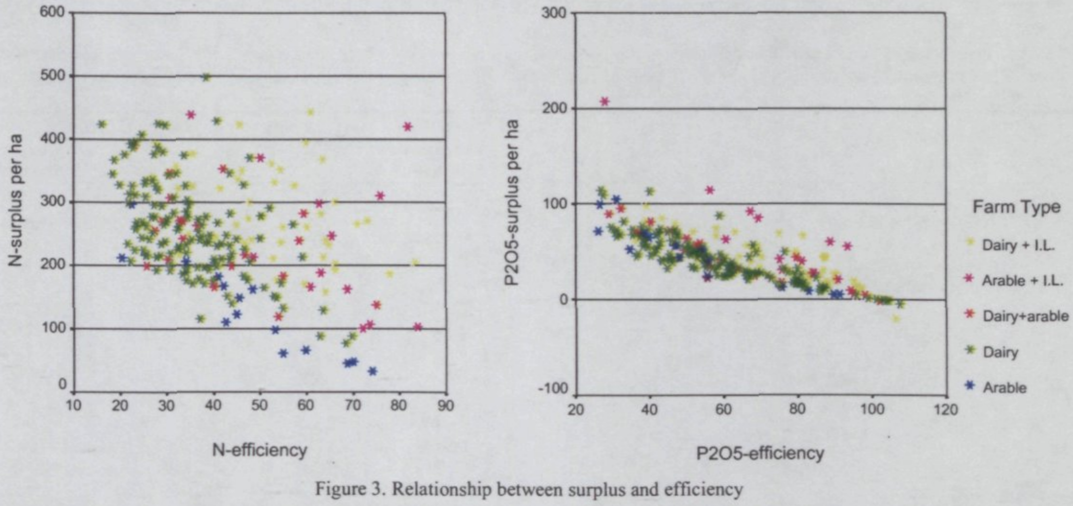


Figure 3. Relationship between surplus and efficiency

Figure 3 shows clear negative relationships between efficiency and surplus for both nitrogen and phosphate. The dispersion is somewhat bigger for nitrogen indicating less strong dependency. To quantify the relationships shown in figure 3, Pearson correlation was calculated. These correlations and their significance are shown in table 4.

Table 4. Pearson correlation between surplus and efficiency for nitrogen and phosphate per farm type

	Dairy	Mixed dairy and intensive livestock	Mixed dairy and arable	Arable	Mixed arable and intensive livestock
Nitrogen	-0.54**	-0.36*	-0.51*	-0.93**	-0.42
Phosphate	-0.85**	-0.85**	-0.91**	-0.92**	-0.92**

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

The relationship between nitrogen surplus and efficiency is not equally strong for all farm types. Especially arable and dairy farmers will benefit with regards to nitrogen surpluses if they will first focus on nitrogen efficiency rather then using other strategies like extensivation of the farm through buying land or selling cattle. Considering phosphate, we can see that it is definitely in every farmer's best interest to first work on phosphate efficiency rather then jumping to more extreme measures, regardless of farm type. Both figure 4 and table 4 show that the opportunity exists to reduce nutrient surpluses with relative ease. Increasing efficiency may also have financial consequences since a decrease in waste will result in a decrease in cost. Improving efficiency might therefore be a key issue in battling excess nutrients and realising sustainable nutrient management.

4. Implications of MINAS

Levies and Farm Sustainability

The results from paragraph 3 show large differences between nutrient surpluses and efficiency between and within farm types. The implications of these results with regards to MINAS are shown in table 5. Table 5 shows the percentage of participants that will have to pay a levy and the average levy and standard deviation of the levy (excluding € 0-levies). The first three rows concern actual MINAS surpluses, calculated according to the MINAS system. Since these surpluses may be biased because of tactical decisions regarding build up of stock, the next three rows show the management surplus and its monetary consequences. By 2003 the system will be introduced to all farm types and surpluses will tend toward management surpluses. To give an indication of the impact of the final LFS we calculated the consequences of the new surplus standards and levies of 2003 for the management surpluses of 1998 per ha and total levies. Also, in 1998 phosphate from chemical fertiliser was exempt from taxation. It is unclear if this exemption will hold. If not, the consequences in 2003 are shown in the last three rows.

Table 5. Percentage of participants that did not meet the standards in 1998 (enforced only for farms > 2.5 LU/ha) and will not meet them in 2003 (assuming no change and applying standards for 2003 to 1998 management surpluses) and average (standard deviation) and range of levies.

	Dairy	Mixed dairy and intensive livestock	Mixed dairy and arable	Arable	Mixed arable and intensive livestock
1998					
% MINAS surplus > standards	29%	52%	29%	6%	15%
Levy €/ha	41 (39)	66 (76)	24 (10)	123*	58 (78)
Range (min.-max.)	2 - 153	3 - 337	14 – 40		3 – 113
% Management surplus > standards	25%	38%	29%	31%	54%
Levy €/ha	44 (42)	32 (30)	32 (23)	72 (136)	149 (258)
Range (min.-max.)	3 - 208	2 - 89	13 – 75	4 - 314	2 – 711
2003					
% Management surplus > standards	85%	75%	90%	56%	85%
Levy €/ha	233 (190)	324 (201)	228 (128)	287 (337)	461 (590)
Range (min.-max.)	9 - 989	20 – 695	60 – 566	26 - 1157	15 – 2059
Total levy €	9242 (7655)	10469 (7522)	12186 (7258)	20033 (27202)	17446 (21209)
Range (min.-max.)	504-33326	858-28783	2871-24071	2453-89782	2871-24071
% Management surplus incl. P_2O_5 (cf) > standards	94%	81%	95%	69%	92%
Levy €/ha	390 (284)	431 (302)	441 (282)	517 (310)	599 (686)
Range (min.-max.)	24 - 1218	22 – 1200	60 – 1167	59 - 1157	5 – 2418

* N = 1, no standard deviation can be calculated

When no actions are taken, most farms, regardless of farm type, will exceed the LFS standards in 2003. Levies per ha differ a lot, showing the difference between farms that are close to meeting the standards and those who lag behind. The average levy per ha is lowest for mixed dairy and arable farms and highest for mixed arable and intensive livestock farms. The ranges of the levies per ha show that the spread is large, from hardly any levy up to € 2059 per ha. When phosphates from chemical fertiliser are included in the surplus, the percentage of farmers that do not make the standards goes up, as well as the average levy farmers have to pay. Arable farmers seem to be most dependent on phosphates from chemical fertilisers. When this is included in the surpluses, another 13% of arable farms will be taxed with a levy that is € 230 higher. The other farm types show similar results but not as severe. Apparently, these farms supply most of their need for phosphate with manure. Looking at total levies, we can see that the average levy is lowest for dairy farmers and highest for arable farms. It also shows that on individual farm level levies can be very high, causing a serious threat to continuity. It is clear from table 5 that farmers will have to start acting, not only to meet the standards but also to maintain a financially viable farm.

In paragraph 3 we showed that the relationship between financial and nutrient results is negative, meaning a sustainable nutrient management. When correlating gross margin after the levies for 2003 with nutrient surpluses, again dairy farms and mixed dairy and arable farms show significant correlations between N-surplus and gross margin. The correlations are larger however, indicating a strengthening of the sustainable relationship. If we take into account phosphates from chemical fertiliser, the negative correlation between the P_2O_5-surplus and gross margin is significant for arable farms (α=0.05), dairy and mixed dairy and intensive livestock farms (α=0.01). It appears that the clearest sustainable relationships appear for specialised dairy farms. Mixed dairy and intensive livestock farms only show a significant sustainable relationship with regards to phosphate and only when phosphates from chemical fertilisers are taken into account. Significant sustainable relationships exist for mixed dairy and arable farms with regards to nitrogen, not phosphates and specialised arable farms display a sustainable relationship between gross margin and P_2O_5 surplus only when phosphates from chemical fertiliser are taken into account.

Feasibility of LFS

Whether or not it is feasible to meet the surplus standards in 2003 depends on the current level of nutrient management on the farm. Farms with large deviations from the final standards will have more difficulty meeting the standards then do farms that are already close to meeting the standards. The further farms are apart from the standards, the less feasible it will be for Dutch agriculture to meet the 2003 standards. This would mean that, unless radical changes like a restructuring will be introduced, Dutch agriculture will not be able to meet the environmental safety standards set by the government. Figure 4 shows the deviations from the final N standard as well as the final P_2O_5 standards for the different farm types.

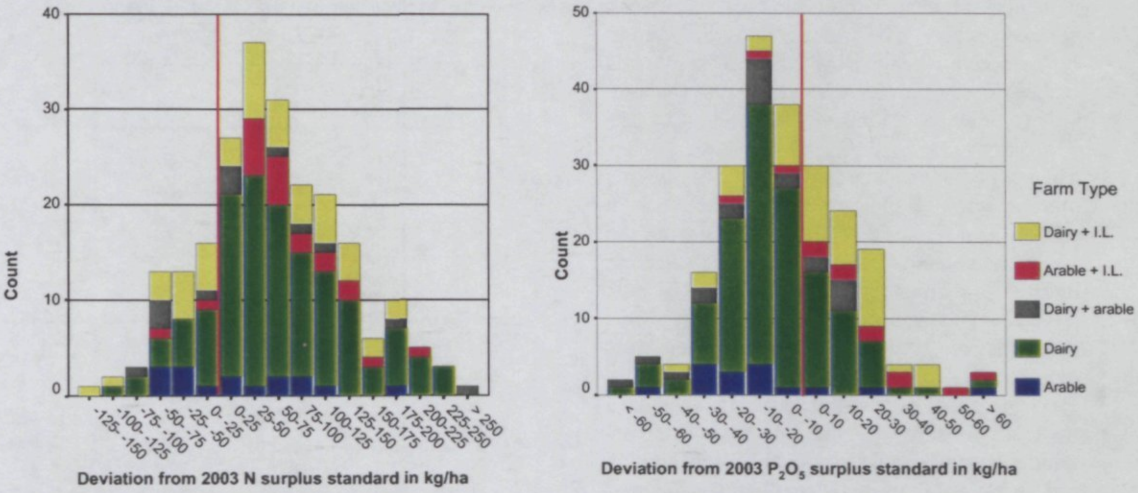


Figure 4. Spread of deviations from final N and P_2O_5 surplus standards

The left panel in figure 4 shows that most farmers (79%) do not comply with the final N surplus standards as of yet. The bigger part of those farms (36%) is within a range of 50 kg N per ha, 53% within 75 kg N per ha. This indicates that more than half the group can probably meet the standards in time, with relatively little effort. The other half will have to put forward considerably more effort in order to comply with the requirements for N. The right panel shows that the larger part of the FDP participants (63%) already meets the 2003 standards for phosphate in 1998 (when phosphates from chemical fertiliser are not taken into consideration). Almost two thirds (64%) is within 20 kilograms per ha of the standard. Figure 5 also shows that little difference between farm types exists with regards to meeting the standards. This can be said for both N and P_2O_5 although the most intensive farm type, mixed dairy with intensive livestock farming, has more problems with phosphate than do the other farm types.

Application Standards and Safe Nutrient Management

Beside a decrease in LFS, farmers must also take into account application standards for nitrogen from manure. If they exceed the application standards it is mandatory to contract a farmer who has excess room for placement. Table 6 shows the average application standards and ranges per farm type, the percentage of participants that exceeds the nitrogen application standards and the level of the excess or room. Nitrogen production is based on standard production figures for 1998 (Ministry of LNV, 1998). In the future, nitrogen production standards will be differentiated for milk production, type of stable, animal breed and so on. This will cause the percentage of farmers that exceed the application standard to decrease.

Table 6. Percentage of participants exceeding the application standards for N from manure in 2002 and 2003 and average amount N excess or shortage. Excess is calculated for the percentages of participants that exceeds the application standards and room for placement for those who do not

	Dairy	Mixed dairy and intensive livestock	Mixed dairy and arable	Arable	Mixed arable and intensive livestock
Application standard 2002	287 (11)	276 (20)	243 (22)	172 (6)	179 (24)
% exceeding application standards2002	73%	98%	48%	0%	85%
Average excess	71 (70)	220 (144)	113 (67)		239 (406)
Average room for placement	26 (24)	43*	52 (31)	169 (4)	13 (7)
Application standard 2003	239 (10)	229 (17)	210 (13)	171 (4)	176 (15)
% exceeding application standards2003	96%	100%	67%	0%	85%
Average excess	98 (72)	262 (148)	111 (83)		244 (405)
Average shortage	25 (19)		45 (29)	168 (6)	13 (7)

* N = 1, no standard deviation can be calculated

Offering contracts by those who have room for placement will probably become very lucrative since farmers who have an excess N production are legally forced to have an agreement. This will cause the development of a market for contracts with high prices due to low supply and high demand, making contracts scarce. The contract does not have to be enforced when a low MINAS surplus is realised by the farmer who has excess manure. He may then use it himself.

The application standards do not guarantee low nutrient surpluses. Figure 5 shows the nitrogen surplus as a function of the deviation from the application standard that will become effective in 2003. Each dot represents a farm. Red dots indicate a farm which does not meet the surplus standards of 2003 yet, whereas green dots represent those farms which do. Apparently, even farms that exceed the application standard with almost 600 kg N/ha meet the MINAS standards and are able to generate a low surplus and in doing so pose a small environmental burden on their farmland. On the other hand, farms that have plenty of room for manure

Figure 5. N surplus with respect to the application standard of 2003

placement (left of the vertical 0-line) manage to achieve lower surpluses but at the same time do not meet the MINAS standards since their land, which is mostly arable land has lower surplus standards (table 1). A similar picture can be drawn for phosphate. Application standards are almost 100% correlated with livestock density of the farm. On the horizontal axes we could therefore also put the LU/ha and generate a similar figure, from which we can draw similar conclusions.

Figure 5 showed that application standards do not guarantee safe nutrient management at the farm level. They might bring about 'balanced fertilisation' at a national level however, because the excess of organic N, for which no room for placement is available, will have to be taken out of the market. This can be done in several ways. Not only will farmers stop but alternatives for the excess like processing are being investigated. However, balanced fertilisation at a national level does not lead towards a safe drinking water supply. Locally groundwater may be polluted because of farms with less efficient nutrient management and large surpluses per ha. A nutrient accounting system like MINAS can control those farms and is therefore a more effective tool to reach safe nutrient management and maintain a safe drinking water supply. Whether this nutrient management is also financially sustainable remains to be seen. No farm can afford to keep practising nutrient management which leads to high nutrient surpluses per ha. The financial burden is simply too large. They either have to bend or break.

5. Discussion and conclusions

The Nitrate Directive, which focuses on pollution of ground- and surface waters with nitrate caused Dutch policy makers to design a nutrient accounting system called MINAS. If they would not have done so and simply implemented application standards as prescribed by the European Community, this would have led to a serious threat to Dutch agriculture, which is very intensive. Another reason behind MINAS is that studies showed that trying to solve a pollution problem with general measures does not work. Focusing on the individual farmer has two advantages. First, individuals are considered polluters and are individually charged with the costs of their pollution, and second, individuals have control over their pollution problem and will be able to deal with it on an individual level instead of being forced into general measurements, especially since each farm has its own specific characteristics.

The MINAS accounting system is a farm gate approach. Not only does it not take into account changes in stock but it also neglects inputs like atmospheric deposition, net mineralisation of soil organic nitrogen and biological nitrogen fixation through free living nitrogen fixing soil organisms and leguminous crops that do not enter the gate but are the result of natural processes (Oenema and Heinen, 1999). The reason for choosing a system like MINAS is the simplicity of the system. Considerable difference may occur however, especially for nitrogen, since the N-cycle shows several leaks due to volatilisation, denitrification and leaching. That is why the MINAS surplus is considered the farm excess to take into account. Studies have shown that when surplus standards are met, groundwater pollution will be below safety standards.

Meeting the final surplus standards for nitrogen will take some effort of farmers. A large part of the farms will manage to fulfil the environmental requirements for 2003 with relative ease since they are in close proximity to the LFS already. The current situation for phosphate shows that most farms already meet the final surplus standards. Meeting the phosphate standards will pose the biggest problem for the most intensive livestock farms. An analysis of efficiency showed that farms with low efficiency have high nutrient surpluses for both nitrogen and phosphate. This means that surpluses can be decreased by mainly focussing on efficiency. Combining the proximity to the LFS with efficiency measures, we can conclude that most farmers will be able to meet the final levy free surpluses if they improve their efficiency.

The exemption of phosphate from chemical fertiliser from MINAS calculations favours those who use relatively less phosphate from manure and more phosphate from chemical fertiliser. This fact makes it harder in the future for cattle farmers to contract an arable farmer with room for placement of manure, since he can fairly easy avoid a levy by using chemical fertiliser instead of manure. Leaching does not discriminate between chemical and organic phosphates however but is mainly based on soil type and conditions. One way to solve this problem is to include phosphates from chemical fertiliser into the system to be taxed. This will also lead towards the most sustainable nutrient management relationships.

Application standards will most likely have a negative effect on income because of the increasing price of manure contracts. On top of that these standards do, by no means, guarantee safe nutrient management at the farm level. They might lead to balanced fertilisation on a national level but this could very well be accompanied by individual excesses which can still cause a threat to safe drinking water. The deviation from the application standard is for almost a 100% positively correlated with livestock intensity of the farm. The analysis in paragraph 4 showed that application standards do not guarantee safe nutrient management, neither will the resulting restriction on livestock density.

Data analysis on differences in ranges of MINAS and management surplus showed that decisions at farm level are still largely dictated by monetary arguments. The FDP participants discussed here are all common farms, without organic or ecological imperatives. The decision whether or not to have manure supplied by a third party will not be based on environmental arguments as long as room for placement is available because the financial compensation is too high to let go by, even though it would be better for the environment. Furthermore, inputs are purchased when it is economically interesting. Since MINAS considers all purchased inputs to be used in the same year, constraints are put on the economic decision to purchase inputs.

The study showed that MINAS, unlike application standards, will lead towards sustainable nutrient management at the individual farm level. Furthermore, changes in individual farm layout characteristics like livestock density are only to be considered when the limits of nutrient efficiency are reached. The administrative burden MINAS lays on farmers should not be underestimated however. Instead of one bookkeeping system they are now forced to uphold a second one. In time, habituation will lead to general acceptance of the system. Farmers in the FDP project already stated that it provides and enormous insight into their management and that gathering and analysing farm data becomes more and more normal to them. Adjusting to this new way of farming might prove more difficult, since mental boundaries exist. Producing less then technically possible in order to protect the environment is a relatively new thought in Dutch agriculture. Furthermore, farmers seem to feel as if they are producing on an unstable optimum and a reduction in fertiliser will lead to an estimated decrease in both quality and quantity far larger then estimated with growth curves. Risk attitudes of farmers are important here and a little more daring with regards to experimenting on feeding and fertilisation rates might prove necessary to meet the standards. Further research should therefore focus on several aspects of nutrient management. First of all technical relationships between farm layout, farm management and nutrient and financial results should be investigated to get a clear picture of which parts of the farm have most impact on results and should therefore firstly be optimised. Second, the background of decisions of farmers should be examined to see why farmers make certain decisions with regards to optimising nutrient and financial management.

References

Aarts, H.F.M., Biewinga, E.E., Keulen, H. van, 1992, *Dairy farming systems based on efficient nutrient management*, Netherlands Journal of Agricultural Science, 40, pp. 285-299

Aarts, H.F.M., Hack-Ten Broeke, M.J.D., Groot, W.J.M., de, Dijkstra, J.P., 1994, *Nitrogen budgets and nitrate leaching from an experimental system for sustainable dairy farming at 'De Marke'*, In: Mannetje, l. 't, Frame, J. (Eds.), Grassland ans Society, Proceedings of the 15[th] General Meeting of the European Grassland Federation June 6-9, Wageningen Pers, pp. 377-381

Anonymous, 1996, *Project plan 'Praktijkcijfers'*, LTO Nederland (In Dutch)

Brandt, H.M.P. van den, Smit, H.P, 1998, *Mineral Accounting: the way to combat eutrophication and to achieve drinking water objective*, Environmental Pollution, 102, pp. 705-709

Brinkhorst, L.J., 2000, *Fourth report of progress, manure and ammonia policy*, Correspondence with the parliament, www.minlnv.nl/infomart/parlement/2000/par00050.htm, (in Dutch)

Brinkhorst, L.J., Pronk, J.P, 1999, *Integral approach of the manure problem*, Correspondence with the parliament, www.minlnv.nl/infomart/parlement/1999/par99179.htm, (in Dutch)

Brouwer, F.M., Kleinhanss, W. (Eds.), 1997, *The implementation of Nitrate policies in Europe: Process of change in Environmental Policy and Agriculture*, Vauk, Kiel

Bruchem, J. van, Schiere, H., Keulen, H. van, 1999, *Dairy farming in the Netherlands in transition towards more efficient nutrient use*, Livestok production Science, 61, pp. 154-153

Carpenter, S.R., Caraco, N.F., Correll, D.L., Howarth, R.W., Sharpley, A.N., Smith, V.H., 1998, *Nonpoint pollution of surface waters with phosphorus and nitrogen*, Ecological Applications, 8 (3), pp. 559 - 568

CBS, AERI,1999, *Agricultural and horticultural data 1999*, Agricultural Economic Research Insitute, The Hague

EEC, 1991, *Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agriculturtal sources*, Official Journal L375, 31.12.1991, p. 1.

Frederiksen, B.S., 1994, *National responses to the EC Nitrate Policy*, Journal of Environmental Planning and Management, 38 (2), pp. 253-263

Goodchild, R.G., 1998, *EU Policies for the reduction of nitrogen in water: the example of the Nitrates Directive*, Environmental Pollution 102, pp. 737-740

Griffith, D., 1999, *Exaggerating environmental health risk: The case of toxic dinoflagellate Pfiesteria*, Human Organization, 58 (2), pp. 119-127

Harrison, R.M., 1996, *Pollution: causes, effects and control*, 3[rd] edition, The Royal Society of Chemistry, Cambridge

Heathwaite, A.L., Johnes, P.J., Peters, N.E., 1996, *Trends in nutrients*, Hydrologic Processes, 10 (2), pp. 263-293

Meer, H.G., van der, Putten, A.H.J., van der, 1995, *Reduction of nutrient emissions from ruminant livestock farms*, In G.E. Pollot (Ed.),Grassland into the 21[st] Century: Challenges and opportunities, Proceedings of the 50[th] Anniversaru Meeting of the British Grassland Society, Harrogate, 4-6 December, 1995, pp.118-134

Miller, R.W., Donahue, R.L., 1995, *Soils in our environment*, 5th edition, Prentice Hall, Englewood Cliffs

Ministerie van LNV, 1998, *Tabel fosfaat en stiksofproductiegetallen*, www.minlnv.nl/mestbeleid/, (in Dutch)

Oenema, O., Boers, P.C.M., Eerdt, M.M., Fraters, B., Meer, H.G., van der, Roest, C.W.J., Schröder, J.J., Wilems, W.J., 1998, *Leaching of nitrate from agriculture to groundwater: the effect of policies and measures in the Netherlands*, Environmental Pollution, 102, pp. 471-478

Oenema, O., Roest, C.W.J., 1998, *Nitrogen and phosphorus losses from agriculture into surface waters; the effects of policies and measures in the Netherlands*, Water Science and Technology, 37 (2), pp 19-30

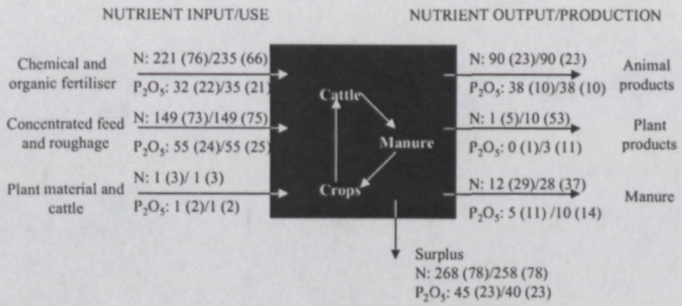
Oenema, O., Heinen, M., 1999, *Uncertainties in nutrient budgets due to biases and errors*, In Smaling, E.M.A., Oenema, O., Fresco, L.O. (Eds.), 1999, Nutrient Disequilibria in agroecosystems, CABI Publishing

Rauschkolb, R.S., Hornsby, A.G., 1994, *Nitrogen management in irrigated agriculture*, Oxford University Press, New York

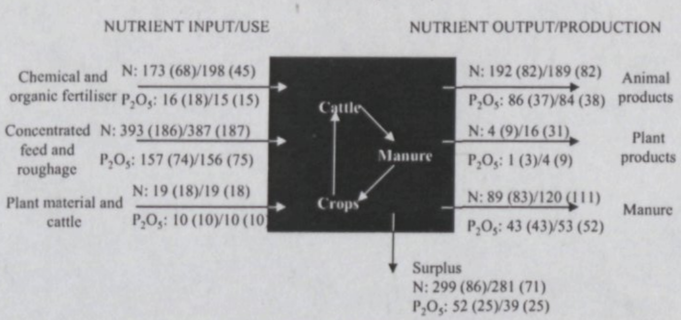
Walle, F.B. de, Sevenster, J., 1998, *Agriculture and the Environment: Minerals, Manure and Measures*, Kluwer Academic Publishers, Dordrecht

Willems, W.J., Vellinga, T.V., Oenema, O., Schröder, J.J., Meer, H.G., van der, Fraters, B., Aarts, H.F.M., 2000, *Onderbouwing van het Nederlandse derogatieverzoek in het kader van de Europese Nitraatrichtlijn*, RIVM, Bilthoven, (in Dutch with English summary)

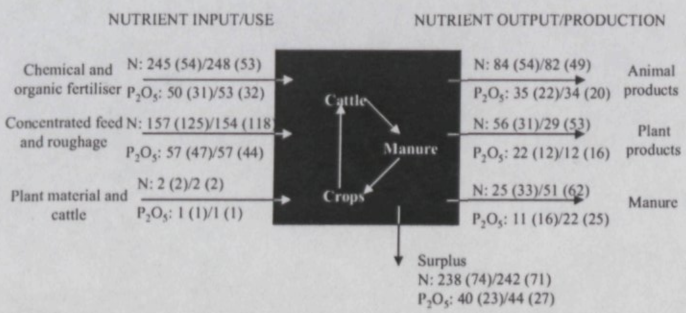
DAIRY FARMS (N = 129)



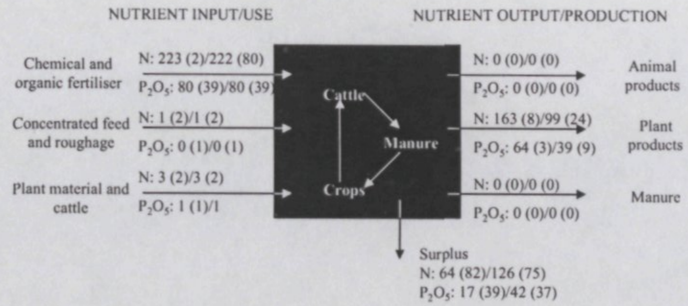
MIXED DAIRY AND INTENSIVE LIVESTOCK FARMS (N = 48)



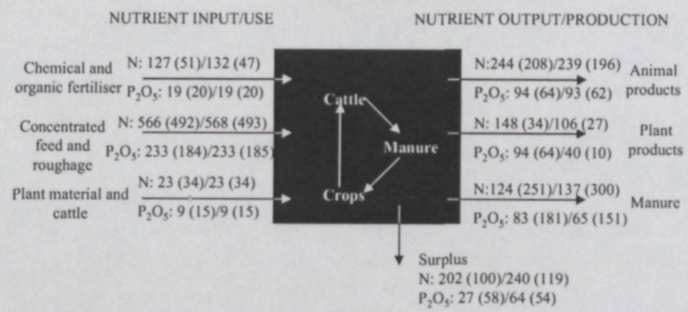
MIXED DAIRY AND ARABLE FARMS (N = 21)



ARABLE FARMS (N = 16)



MIXED ARABLE AND INTENSIVE LIVESTOCK FARMS (N = 13)



The input and output data are averages (and standard deviations) from the MINAS balance whereas the use and production data are adjusted for stock and give therefore better insight in management.