# ENVIRONMENTAL CONSTRAINTS FOR INTENSIVE LIVESTOCK FARMING: THE CASE OF THE DUTCH PROVINCE OF GRONINGEN

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## Introduction

The aim of this paper is to determine the possibilities for the intensive livestock sector in the province of Groningen, the Netherlands. The reason is the crisis in arable farming in this part of the country caused by low prices of certain arable products like cereals. Based on plausible assumptions the paper shows that the possibilities for this kind of activities in Groningen are limited and therefore cannot be considered as a major solution to the problems in agriculture in this region.

During the past twenty years, intensive livestock farming in the Netherlands has increased considerably. An important reason for this was the low cost of imports of concentrates through the port of Rotterdam. A consequence of this was that the link between the production capacity of cultivated land and manure production has disappeared resulting in large manure surpluses. These surpluses mainly have a regional character. However, depending on the standards used, there is also a national manure surplus. There are two reasons for the growth of the intensive livestock sector in Groningen.

The first reason is that intensive livestock farming is concentrated in the south and the east of the Netherlands. Now the capacity for intensive livestock farming in these areas is fully used causing farmers to look for opportunities for expansion elsewhere. The second reason is the low prices for a number of arable products like cereals. Up till now, arable farming is the main agricultural sector in the province of Groningen.[2] As a result of recent changes in the Common Agricultural Policy originating from budgetary problems

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2 Consulentschap voor Landbouw in Groningen, 1992. *Provinciale Landbouwontwikkelingsnota Groningen*. Groningen.

cereals prices are low. This enforces farmers in Groningen to look for alternatives for arable farming. One of the alternatives within agriculture is intensive livestock farming. The conclusion is that there is an external as well as an internal force working on the expansion of the intensive livestock sector in Groningen.

The consequences of two types of manure standards are computed. Firstly phosphate standards and secondly nitrate standards.[3] For phosphate three standards are dealt with: the actual standard, a more strict one and the strictest standard which takes into account the use of artificial fertilizer. In the case of nitrate we are dealing with two standards: the EC guideline with a moderate standard and the strictest standard which takes into account the use of artificial fertilizer. Further, we distinguish between pasture and arable land and we show the effect of a changed diet.

## Manure policy in the Netherlands

The Dutch manure policy is based on two laws:

1. The Law for Soil Protection and the included Resolution for Animal Manure;
2. The Manure Law.

The first law contains rules for the use of animal manure. It tries to offer a common level of soil-protection for the entire country, in order to keep the soil's multifunctionality. The Manure Law is about manure-bookkeeping, manure-levies, tasks of manure-banks and the maximum amount of manure-production allowed. All these things are regulated, in order to protect soil-fertility.

The Law on Soil-protection and the Manure Law are so-called frame-laws. This means that there has been created a juridical scope, in which competences and obligations are described. The actual rules have to be made afterwards by the Minister ("Orders in Council"). This offers the government to respond quickly to changing or special situations.

3 Phosphate is measured as $P_2O_5$, Nitrate is measured as $NO_3$.

## Manure standards

The manure standards are mentioned in the Resolution for Animal Manure.[4] The Dutch Government tries to reduce the phosphate intake through animal manure (the phosphate intake by means of artificial fertilizers remains free). The Government tries to achieve this goal in three steps:

1. Until December 31, 1990: 125 kilograms phosphate per hectare per year on arable land, 350 kilograms phosphate per hectare per year on maïsland, 250 kilograms phosphate per hectare per year on pasture. Farmers are allowed to put more manure on arable land, provided that they will not put more phosphate on one hectare than 250 kilograms in 2 years at a stretch.

2. Phosphate standards after 1990 (kilograms $P_2O_5$ per hectare per year):

| By the end of the year | arable land | maïsland | pasture |
|---|---|---|---|
| 1992 | 125 | 250 | 200 |
| 1993 | 125 | 200 | 200 |
| 1994 | 125 | 150 | 200 |
| 1995 | 125 | 125 | 175 |

3. Until the 31st of December 1999 the end goal is not yet known. Neither when the final standards will be applied, nor what these standards will be are known. These two things depend on the reduction of mineral abundance by (means of) changing the composition of cattle-fodder, the promotion of sales by improving the quality of manure, and the development of manure processing.

The European Community has paid some attention to nitrate as one of the minerals that has to be reduced. The EC has made a guideline, which has to be converted into national legislation. According to this guideline, it is no longer allowed to have more than 25 milligrams of nitrate in 1 litre of drinking water.[5] This goal can be attained in two ways:

4 Ministerie van Justitie, 1991. *Staatsblad van het Koninkrijke der Nederlanden,* nr. 386. Den Haag.
5 European Community, 1991 (December 31), *Publicatieblad van de Europese Gemeenschappen,* nr. L375/1 (91/676/EEG).

1. The nitrate standard; a maximum is posed on the quantity of nitrate a farmer is allowed to put on his land each year (just like the phosphate standard). This quantity is set at 175 kilograms $NO_3$ per hectare per year (animal manure).
2. A package of measures, with which a country can try to achieve the drinking water standard. For instance by building more watercleaning installations. The Dutch Government will probably opt for this possibility.

## Assumptions

In this section the assumptions will be discussed on which the calculations are founded. The results of the calculations will be discussed in the next chapter. The calculations themselves can be found in the appendix.

First, the regions under investigation have to be defined clearly. The province of Groningen has been divided into three regions. The northern region, which is the region called "Hogeland"; the eastern region: the regions called "Nieuw-Oldambt", "Oud-Oldambt", "Veenkoloniën" and "Westerwolde" and finally the western region: The regions called "Zuidelijk Westerkwartier" and "Humsterland". This partition has not only been made on geographical grounds, but also because of the different characteristics of each region: In the northern region there is some intensive livestock farming, some arable land and some gardening as well. But the eastern region is predominantly an arable area, while the western region can be described as a typical pasture area.[6]

Second, Phosphate and nitrate are the two most important minerals, when people talk about the manure problem. Therefore research has primarily been concentrated on these two minerals.

Third, an important assumption is that there are no transports of manure. The importance of this assumption will be clear if we regard the fact that Groningen still is a net importer of manure. In the calculations, the assumption of no manure transports means, that the manure production in a certain region will also be used there. So the production can be assumed to be equivalent to the quantity the farmers are allowed to put on their land.

Fourth, in the calculations three standards for phosphate are used:
1. The "present standard"; this is the standard for 1993.
2. The "stricter standard"; this is the standard, according to the Manure Law.

6 Stoffelsma R.J. and D. Strijker, 1991. *De Noordelijke akkerbouw: sector en regio op zoek naar een toekomst.* Stichting Ruimtelijke Economie, Groningen.

3. The "strictest standard"; this standard equals 75% of the "stricter standard". This percentage reflects the usual contribution of animal manure in the soil need for phosphate.[7] The remaining need is covered by fertilizers. These percentages are for nitrate somewhat different: Only 38.7% of the need for nitrate is covered by animal manure.

The "strictest standard" is the most realistic standard, because this standard takes into account the fact that farmers do not only rely on animal manure for their needs for minerals, but also use artificial fertilizers. This standard is closest to the real world situation.

Fifth, in order to arrive at a *standard livestock farm*, the research relies upon figures, given by local authorities, about growth rates of numbers of pigsties, intensive dairy farms and broilers farms. From these numbers an average production of manure per extra labour unit could be calculated.

Sixth, a labour unit is an economic concept, meaning a farm that can be managed by one person. In the context of this research, a labour unit implies 50 dairy-cows, 1725 pigs, *or* 6 times 62,500 broilers (6 "rounds").[8]

Seventh, the calculations have also been applied to the situation in which, due to technological development, the percentage of minerals in animal nutrition has been lowered. The most important way to bring down this percentage is to change the composition of the fodder. This assumption about technological development is not only important for the eventually coming cattle (through expansion of the intensive livestock farming), but also for the already existing cattle. So, the existing production of minerals has to be corrected for the technological development. This is done by multiplying the existing amounts by a ratio number, representing the ratio of mineral production of an average labour unit intensive livestock farming with changed fodder composition and the present situation without the change.

## Results

In this chapter the results of the calculations will be shown. First the northern region, second the eastern region and third the western region. The results will be shown in two tables per region: 1.: number of labour units that can be placed in the intensive livestock farming sector according to the phosphate standards with present fodder composition and after a change in diet of animal

7 Centraal Bureau voor de Statistiek, 1991. *Produktie van dierlijke mest 1988*. Voorburg.
8 Informatie en Kennis Centrum (IKC), 1992. *Brochure*.

nutrition and 2.: number of labour units that can be placed in the intensive livestock farming sector according to the nitrate standards with present composition of animal nutrition and with change in diet.

*The northern region*

*Table 1:* The numbers of labour units intensive livestock farming, that can be placed in the northern region, calculated according to the phosphate standards (without and with a change in diet respectively).

| | Dairy-cattle | Pigs | Broilers |
|---|---|---|---|
| Present standard | 81 | 71 | 40 |
| Stricter standard | 69 | 61 | 34 |
| Strictest standard | 48 | 42 | 24 |
| *With a change in diet:* | | | |
| Present standard | 150 | 132 | 75 |
| Stricter standard | 130 | 114 | 65 |
| Strictest standard | 93 | 82 | 47 |

*Table 2:* The numbers of labour units intensive livestock farming, that can be placed in the northern region, calculated according to the nitrate standards (without and with a change in diet respectively).

| | Dairy-cattle | Pigs | Broilers |
|---|---|---|---|
| EC-guideline | 65 | 57 | 32 |
| Strictest standard | 3 | 3 | 2 |
| *With a change in diet:* | | | |
| EC-guideline | 129 | 114 | 65 |
| Strictest standard | 41 | 36 | 20 |

Two things are remarkable:

1. A change in diet appears to have a great impact on the numbers of labour units that can still be placed. If one might find these reductions in phosphate production as a result of technological development a little bit to optimistic (the figures are taken from research and expectations of the council for agricultural research), one can simply change the figures in the calculations; this automatically leads to lower numbers of placable labour units.

2. The nitrate standards are much more restrictive than the phosphate standards.

*The eastern region (including Oldambt and Peatland Reclamation District)*

*Table 3:* The numbers of labour units intensive livestock farming, that can be placed in the eastern region, calculated according to the phosphate standards (without and with a change in diet respectively).

| | Dairy-cattle | Pigs | Broilers |
|---|---|---|---|
| Present standard | 126 | 111 | 60 |
| Stricter standard | 116 | 102 | 58 |
| Strictest standard | 79 | 70 | 40 |
| *With a change in diet:* | | | |
| Present standard | 238 | 210 | 119 |
| Stricter standard | 220 | 194 | 110 |
| Strictest standard | 158 | 139 | 79 |

*Table 4:* The numbers of labour units intensive livestock farming, that can be placed in the eastern region, calculated according to the nitrate standards (without and with a change in diet respectively).

| | Dairy-cattle | Pigs | Broilers |
|---|---|---|---|
| EC-guideline | 122 | 108 | 61 |
| Strictest standard | 16 | 14 | 8 |
| *with a change in diet:* | | | |
| EC-guideline | 220 | 194 | 110 |
| Strictest standard | 68 | 60 | 34 |

Again it appears that a change in diet has important consequences and that the nitrate standards are more restrictive than the phosphate standards.

In the eastern region there is more room for expansion than in the northern region. This is mainly because there is a difference in land use: In the eastern region there is mainly arable land, while in the northern region there is also some pasture and gardening. A second (minor) explanation for the fact that the eastern region has more room for expansion, is that in this research, the area of the eastern region is a little bit larger than the northern region.

*The western region*

*Table 5:* The numbers of labour units intensive livestock farming, that can be placed in the western region, calculated according to the phosphate standards (without and with a change in diet respectively).

| | Dairy-cattle | Pigs | Broilers |
|---|---|---|---|
| Present standard | 36 | 32 | 18 |
| Stricter standard | 12 | 10 | 6 |
| Strictest standard | -1 | -1 | 0 |
| *After a change in diet:* | | | |
| Present standard | 90 | 79 | 45 |
| Stricter standard | 47 | 42 | 24 |
| Strictest standard | 26 | 23 | 13 |

*Table 6:* The numbers of labour units intensive livestock farming, that can be placed in the western region, calculated according to the nitrate standards (without and with a change in diet).

| | Dairy-cattle | Pigs | Broilers |
|---|---|---|---|
| EC-guideline | -23 | -20 | -12 |
| Strictest standard | -59 | -52 | -30 |
| *With a change in diet:* | | | |
| EC-guideline | 49 | 43 | 24 |
| Strictest standard | -3 | -3 | -2 |

In this region the room for expansion is the least. Here again the note must be made that the area is not as large as the eastern region. However, what obviously appears is that, if the nitrate standards will ever be applied, there is no room left for expansion of intensive livestock farming in this region of Groningen. There will even be the need to decrease the number of labour units.

Even if one would only regard the phosphate standards, and one takes into account the fact that farmers do not only rely on animal manure (strictest standard), it is clear that there is no possibility for expansion, whatsoever. Even a change in diet will not offer great possibilities to expand intensive livestock farming.

## Conclusions

One can draw several conclusions from this research:

1. There is still some room for expansion in this part of the Netherlands, although the possibilities for expansion are not as great as one would expect in such a relatively "clean" area. The possibilities for expansion are the greatest in the eastern region and the least in the western region.
2. Another important conclusion of this research is that technological improvement, by means of changing the diets, has a great impact on the possibilities to expand intensive livestock farming.
3. On top of that, it can be stated from this research, that the room for expansion is very much determined by the relative amount by which the farmers depend on animal manure for the mineral needs of their lands (compare the results of the calculations with the more strict standard or the EC-guidelines, to those with the strictest standard!).
4. Probably the most striking fact is the great difference which appears to exist between the room for expansion based on phosphate standards and the room for expansion based on nitrate standards. This difference can very well be shown, by taking a look at the western region. Regarding the phosphate standards, there is still a little room, but regarding the nitrate standards, there is no room left. Then sanitating of some intensive livestock farming may be necessary.

The Dutch government might opt for the package of measurements to satisfy the nitrate guideline, imposed by the European Council.[9] This means that the Dutch farmers will not have to cope with the nitrate guidelines. This does not effect the conclusion that, in order to arrive at a sustainable agriculture, the numbers of labour units employed in the intensive livestock farming sector may not be increased dramaticly. Provincial officials will have to be aware of the developments, so the "manure-deficit" situation will not change into a "manure-excess" situation, because, it is always much easier to fulfil such a deficit, than to reduce a manure-excess.

Although the assumptions are taken cautiously, one might want to change some of them. This can easily be done in the computerprogramme which has been used for the calculations. For instance, in this study transports of manure have not been taken into account. If some transports are assumed, the results will change accordingly, but the calculation itself will remain the same and the computerprogramme will be able to give these results. Other assumptions that can be modified are the division of the different categories of intensive livestock farming by the expansion of the numbers of labour units intensive

9 EEC, *Op. cit.*

livestock farming; other governmental standards for the use of minerals; the figures used representing the manure production of animals. If one would like to have one of these, or other, variables to be changed, this can easily be done by changing these variables. In this way it is also possible to calculate the room for expansion of intensive livestock farming for other provinces.

## Appendix

We will now explain the calculation of extra room for intensive livestock farming in the three different regions. This explanation is about computation 1 (phosphate standards, without change in diet), but the other three are similar.

To find out what quantities of phosphate can be produced extra, we have to know how much production already exists. This is depicted at step one (for an explanation about the partition of Groningen into three regions, and other assumptions, see Section "assumptions").[10]

As can be concluded the section 'manure standards', it is important to know how many hectares of land are used for growing vegetables and how many used for pasture. These numbers are mentioned at step two.[11]

Because it is assumed that there are no transports of manure, the amounts the farmers are allowed to put on their land equal the maximum production. Multiplication of the hectares by the manure standards result in the maximal allowed amounts of phosphate production per year, for all three regions.[12] The extra amount that can be produced equals the difference between the maximum quantity and the existing production. This is what's happening at step three (for all three regions and all three standards).

At step four the production of phosphate of an average labour unit intensive livestock farming have been calculated. This has been done by multiplying the numbers of animals by the phosphate production of each animal.[13]

At the fifth step, the amount of phosphate production, as a result of one extra average labour unit intensive livestock farming has been considered. This has been done by taking a division of the different types of intensive livestock farming, in the way it expanded in the last five years.

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10Centraal Bureau voor de Statistiek, *Op. cit.*
11Centraal Bureau voor de Statistiek, *Op. cit.*
12 For phosphate standards: Ministerie van Justitie, *Op. cit.* For nitrate standards: European Community, *Op. cit.*
13 Informatie en Kennis Centrum (IKC), *Op. cit.*
Coppoolse J., A.M. van Vuuren, J. Huisman, W.M.M.A. Janssen, A.W. Jongbloed, N.P. Lenis and P.C. Simons, 1990. *De uitscheiding van Stikstof, Fosfor en Kalium door landbouwhuisdieren, Nu en Morgen*. DLO, Wageningen.

The sixth step is dividing the extra room for phosphate production by the phosphate production of an average labour unit intensive livestock farming. Then it is known for the northern region what number of extra labour units are allowed. Multiplying these numbers by the percentages, mentioned at step five, results in the maximum numbers of labour units that can be placed extra in the northern region, indicated for each kind of intensive livestock farming.

In the two remaining steps, 7 and 8, this is also done for the eastern and the western region.

*Computation 1: Available space for intensive livestock farming based on phosphate standards (without a change in diet).*

1. How much manure-production is there already (in kilograms phosphate per year)

| | |
|---|---|
| The northern region | 951,000 |
| The eastern region | 1,766,000 |
| The western region | 2,241,000 |

2. Available pasture and arable land (hectares) respectively in:

| | | |
|---|---|---|
| The northern region | 9,142 | 30,635 |
| The eastern region | 8,075 | 60,202 |
| The western region | 19,233 | 4,092 |

Manure standards (kilograms phosphate per hectare per year):

| | Pasture | Arable land |
|---|---|---|
| Present standard | 200.00 | 125.00 |
| Stricter standard | 125.00 | 125.00 |
| Strictest standard | 93.75 | 93.75 |

Allowed maximum quantities of phosphate computed with the present standard (in kilograms per year) in:

| | on pasture | on arable land | in total |
|---|---|---|---|
| The northern region | 1,828,400 | 3,829,375 | 5,657,775 |
| The eastern region | 1,615,000 | 7,525,250 | 9,140,250 |
| The western region | 3,846,600 | 511,500 | 4,358,100 |
| The same calculation, based on the stricter standard: | | | |
| The northern region | 1,142,750 | 3,829,375 | 4,972,125 |
| The eastern region | 1,009,375 | 7,525,250 | 8,534,625 |
| The western region | 2,404,125 | 511,500 | 2,915,625 |
| The same calculation, based on the strictest standard: | | | |
| The northern region | 857,062 | 2,872,031 | 3,729,093 |
| The eastern region | 757,031 | 5,643,938 | 6,400,969 |
| The western region | 1,803,093 | 383,625 | 2,186,718 |

3. How many kilograms phosphate can be placed extra in the northern region:

| | |
|---|---|
| Present standard | 5,657,775 - 951,000 = 4,706,775 |
| Stricter standard | 4,972,125 - 951,000 = 4,021,125 |
| Strictest standard | 3,729,093 - 951,000 = 2,778,093 |

The same calculations for the eastern region:

| | |
|---|---|
| Present standard | 9,140,250 - 1,766,000 = 7,374,250 |
| Stricter standard | 8,534,625 - 1,766,000 = 6,768,625 |
| Strictest standard | 6,400,969 - 1,766,000 = 4,634,969 |

The same calculations for the western region:

| | |
|---|---|
| Present standard | 4,358,100 - 2,241,000 = 2,117,100 |
| Stricter standard | 2,915,625 - 2,241,000 = 674,625 |
| Strictest standard | 2,186,718 - 2,241,000 = -54,281 |

4. An average labour unit intensive livestock farming has got:
50 cows, 1725 pigs or 375,000 broilers. These animals produce each per year the following quantities of phosphate (in kilograms):

| | |
|---|---|
| Per cow | 44.00 |
| Per pig | 7.40 |
| Per broilers | 0.24 |

This means a production of phosphate for every type of farming (in kilograms per year):

| | | | | | |
|---|---|---|---|---|---|
| Intensive dairy farming | 50 | * | 44.00 | = | 2,200 |
| Intensive pig farming | 1,725 | * | 7.40 | = | 12,765 |
| Broilers | 375,000 | * | 0.24 | = | 90,000 |

5. If an increase of intensive live-stock farming with one labour unit occurs, it will be divided in these types:

| | |
|---|---|
| Intensive dairy farming | 42 percent = 0.42 |
| Intensive pig farming | 37 percent = 0.37 |
| Broilers | 21 percent = 0.21 |

This expansion will lead to an increase of phosphate production (in kilograms per year) with:

| | | | | |
|---|---|---|---|---|
| Intensive dairy farming | 0.42 * | 2,200 | = | 924 |
| Intensive pig farming | 0.37 * | 12,765 | = | 4,723 |
| Broilers | 0.21 * | 90,000 | = | 18,900 |
| Total | | | | 24,547 |

6. Division of the available room per region by the extra production of phosphate results in the numbers of labour units intensive livestock farming that can be placed extra in these regions.

The northern region:

| | |
|---|---|
| Present standard: | 4,706,775 / 24,547 = 191.745 |
| Stricter standard: | 4,021,125 / 24,547 = 163.813 |
| Strictest standard | 2,778,093 / 24,547 = 113.174 |

These figures should be interpreted as follows: Under the present standard can be placed in the northern region:
0.42 * 191.745 = 81 Intensive dairy farming
0.37 * 191.745 = 71 Intensive pig farming
0.21 * 191.745 = 40 Broilers

Under the stricter standard:
0.42 * 163.813 = 69 Intensive dairy farming
0.37 * 163.813 = 61 Intensive pig farming

0.21 * 163.813 = 34 Broilers

And under the strictest standard:
0.42 * 113.174 = 48 Intensive dairy farming
0.37 * 113.174 = 42 Intensive pig farming
0.21 * 113.174 = 24 Broilers

7. For the eastern region are the calculations analogous. So, first of all the available room is divided by the extra production of phosphate:

| | |
|---|---|
| Present standard | 7,374,250 / 24,547 = 300,413 |
| Stricter standard | 6,768,625 / 24,547 = 275,741 |
| Strictest standard | 4,634,969 / 24,547 = 188,820 |

Also this time the division of the labour units in the different categories is taken into account. Under the present standard can be placed extra:
0.42 * 300,413 = 126 Intensive dairy farming
0.37 * 300,413 = 111 Intensive pig farming
0.21 * 300,413 = 63 Broilers

And under the stricter standard:
0.42 * 275,741 = 116 Intensive dairy farming
0.37 * 275,741 = 102 Intensive pig farming
0.21 * 275,741 = 60 Broilers

And under the strictest standard:
0.42 * 188,820 = 79 Intensive dairy farming
0.37 * 188,820 = 70 Intensive pig farming
0.21 * 188,820 = 40 Broilers

8. Finally, the calculations for the western region are presented. First of all the available room is divided by the extra production of phosphate:
2,117,100 / 24,547 = 86.247
674,625 / 24,547 = 27.483
-54,281 / 24,547 = -2.211

So, under present standard is in the western region still room for:
0.42 * 86.247 = 36 Intensive dairy farming
0.37 * 86.247 = 32 Intensive pig farming
0.21 * 86.247 = 18 Broilers

Under the stricter standard:
0.42 * 27.483 = 12 Intensive dairy farming
0.37 * 27.483 = 10 Intensive pig farming
0.21 * 27.483 = 6 Broilers

And under the strictest standard:
0.42 * -2.211 = -1 Intensive dairy farming
0.37 * -2.211 = -1 Intensive pig farming
0.21 * -2.211 = 0 Broilers

*Computation 2: Available extra space for intensive livestock farming based on nitrate standards (without a change in diet).*

1. How much manure is there already? (in kilograms nitrate)

| | |
|---|---|
| The northern region | 2,411,000 |
| The eastern region | 3,433,000 |
| The western region | 5,517,000 |

2. How much room is there?

Numbers of hectares pasture resp. arable land in:

| | | |
|---|---|---|
| The northern region | 9,142 | 30,635 |
| The eastern region | 8,075 | 60,202 |
| The western region | 19,233 | 4,092 |

Nitrate standards (kilograms nitrate per hectare per year):

| | Pasture | Arable land |
|---|---|---|
| EC-guideline | 170.000 | 170.000 |
| Strictest standard | 65.790 | 65.790 |

Allowed maximum quantities of nitrate computed with EC-guidelines (in kilograms per year) in:

| | on pasture | on arable land | in total |
|---|---|---|---|
| The northern region | 1,554,140 | 5,207,950 | 6,762,090 |
| The eastern region | 1,372,750 | 10,234,340 | 11,607,090 |
| The western region | 3,269,610 | 695,640 | 3,965,250 |

The same calculation for the strictest standard:

| | | | |
|---|---|---|---|
| The northern region | 601,452 | 2,015,477 | 2,616,929 |
| The eastern region | 531,254 | 3,960,690 | 4,491,944 |
| The western region | 1,265 | 269,213 | 1,534,552 |

3. How many kilograms nitrate can be placed extra in the northern region:

| | | | | | |
|---|---|---|---|---|---|
| EC-guideline | 6,762,090 | - | 2,411,000 | = | 4,351,090 |
| Strictest standard | 2,616,929 | - | 2,411,000 | = | 205,929 |

The same calculation for the eastern region:

| | | | | | |
|---|---|---|---|---|---|
| EC-guideline | 11,607,090 | - | 3,433,000 | = | 8,174,090 |
| Strictest standard | 4,491,944 | - | 3,433,000 | = | 1,058,944 |

And for the western region:

| | | | | | |
|---|---|---|---|---|---|
| EC-guideline | 3,965,250 | - | 5,517,000 | = | -1,551,750 |
| Strictest standard | 1,534,551 | - | 5,517,000 | = | -3,982,448 |

4. An average labour unit intensive livestock farming has got: 50 cows, 1.725 pigs or 375.000 broilers. These animals produce each per year the following quantities of nitrate (in kilograms):

| | |
|---|---|
| Per cow | 124.00 |
| Per pig | 11.60 |
| Per broiler | 0.23 |

This means a production of nitrate for every type of farming (in kilograms per year):

| | | | | | |
|---|---|---|---|---|---|
| Intensive dairy farming | 50 | * | 124.00 | = | 6,200 |
| Intensive pig farming | 1,725 | * | 11.60 | = | 20,010 |
| Broilers | 375,000 | * | 0.23 | = | 86,250 |

5. If an increase of intensive live-stock farming with one labour unit occurs, it will be divided in these types:

| | |
|---|---|
| Intensive dairy farming | 42 percent = 0.42 |
| Intensive pig farming | 37 percent = 0.37 |
| Broilers | 21 percent = 0.21 |

This expansion will lead to an increase of nitrate production (in kilograms per year) with:

| | | | | | |
|---|---|---|---|---|---|
| Intensive dairy farming | 0.42 | * | 6,200 | = | 2,604 |
| Intensive pig farming | 0.37 | * | 20,010 | = | 7,404 |
| Broilers | 0.21 | * | 86,250 | = | 18,113 |
| Total | | | | | 28,121 |

6. Division of the available room per region by the extra production of nitrate results in the numbers of labour units intensive livestock farming that can be placed extra in these regions.

The northern region:

| | | |
|---|---|---|
| EC-guideline | 4,351,090 / 28,121 = | 154.727 |
| Strictest standard | 205,929 / 28,121 = | 7.323 |

These figures should be interpreted as follows. Under the EC-guideline can be placed in the northern region:
0.42 * 154.732 = 65 Intensive dairy farming
0.37 * 154.732 = 57 Intensive pig farming
0.21 * 154.732 = 32 Broilers

Under the strictest standard there can be placed:
0.42 * 7.323 = 3 Intensive dairy farming
0.37 * 7.323 = 3 Intensive pig farming
0.21 * 7.323 = 2 Broilers

7. For the eastern region the calculations are analogous. So, first of all the available room is divided by the extra production of nitrate:

| | | |
|---|---|---|
| EC-guideline | 8,174,090 / 28,121 = | 290.677 |
| Strictest standard | 1,058,944 / 28,121 = | 37.657 |

Also this time the division of the labour units in the different categories is taken into account.

Under the EC-guidelines can be placed extra:
0.42 * 290.684 = 122 Intensive dairy farming
0.37 * 290.684 = 108 Intensive pig farming
0.21 * 290.684 = 61 Broilers

And under the strictest standard:
0.42 * 37.658 = 16 Intensive dairy farming
0.37 * 37.658 = 14 Intensive pig farming
0.21 * 37.658 = 8 Broilers

8. Finally, the calculations for the western region are presented. First of all the available room is divided by the extra production of nitrate:

| | | | |
|---|---|---|---|
| EC-guideline | -1,551,750 / 28,121 | = | -55.181 |
| Strictest standard | -3,982,448 / 28,121 | = | -141.618 |

Under the EC-guidelines can be placed extra:
0.42 * -55.183 = -23 Intensive dairy farming
0.37 * -55.183 = -20 Intensive pig farming
0.21 * -55.183 = -12 Broilers

And under the strictest standard:
0.42 * -141.622 = -59 Intensive dairy farming
0.37 * -141.622 = -52 Intensive pig farming
0.21 * -141.622 = -30 Broilers

*Computation 3: Available space for intensive livestock farming based on phosphate standards (with a change in diet).*

1. If, by changing the diet of the animals the production of phosphate per animal declines, does this not only apply to the numbers of animals that are eventually allowed to expand, but this also applies to the animals that are already in Groningen. So, the present production must also be corrected for this decline. This is done by multiplying the present production by an index. This index is the division of the expected extra production of phosphate with changed diet, by the expected extra phosphate production without changed diet.

   14,315.06 / 24,547.05 = 0.5831682

| | | | | | |
|---|---|---|---|---|---|
| The northern region | 951,000 | * | 0.5831682 | = | 554,593.0 |
| The eastern region | 1,766,000 | * | 0.5831682 | = | 1,029,875.1 |
| The western region | 2,241,000 | * | 0.5831682 | = | 1,306,880.0 |

2. To get the numbers of kilograms of phosphate that can be placed extra in the different regions, these corrected productions have to be subtracted from the available room, which has been calculated in the first appendix.

3. How many kilograms phosphate can be placed extra in the northern region:

| | | | | | |
|---|---|---|---|---|---|
| Present standard | 5,657,775 | - | 554,593 | = | 5,103,181 |
| Stricter standard | 4,972,125 | - | 554,593 | = | 4,417,532 |
| Strictest standard | 3,729,093 | - | 554,593 | = | 3,174,500 |

   The same calculation for the eastern region:

| | | | | | |
|---|---|---|---|---|---|
| Present standard | 9,140,250 | - | 1,029,875 | = | 8,110,375 |
| Stricter standard | 8,534,625 | - | 1,029,875 | = | 7,504,750 |
| Strictest standard | 6,400,969 | - | 1,029,875 | = | 5,371,094 |

   The same calculation for the western region:

| | | | | | |
|---|---|---|---|---|---|
| Present standards | 4,358,100 | - | 1,306,880 | = | 3,051,219 |
| Stricter standard | 2,915,625 | - | 1,306,880 | = | 1,608,744 |
| Strictest standard | 2,186,718 | - | 1,306,880 | = | 879,838 |

4. An average labour unit intensive livestock farming has got: 50 cows, 1,725 pigs or 375,000 broilers. These animals produce each per year the following quantities of phosphate (in kilograms):

| | |
|---|---|
| Per cow | 44.00 |
| Per pig | 7.40 |
| Per broiler | 0.24 |

   But, because of the changed diet, the phosphate production can be reduced by:

| | |
|---|---|
| Per cow | 8 percent |
| Per pig | 35 percent |
| Per broiler | 45 percent |

The phosphate production per animal will be then:

| | | | | | |
|---|---|---|---|---|---|
| Per cow | 0.92 | * | 44.00 | = | 40.480 |
| Per pig | 0.65 | * | 7.40 | = | 4.810 |
| Per broiler | 0.55 | * | 0.24 | = | 0.132 |

This means a production of phosphate for every type of farming (in kilograms per year):

| | | | | | |
|---|---|---|---|---|---|
| Intensive dairy farming | 50 | * | 40.480 | = | 2,024.00 |
| Intensive pig farming | 1,725 | * | 4.810 | = | 8,297.25 |
| Broilers | 375,000 | * | 0.132 | = | 49,500.00 |

5. If an increase of intensive live-stock farming with one labour unit occurs, it will be divided in these types:

| | |
|---|---|
| Intensive dairy farming | 42 percent = 0.42 |
| Intensive pig farming | 37 percent = 0.37 |
| Broilers | 21 percent = 0.21 |

This expansion will lead to an increase of phosphate production (in kilograms per year) with:

| | | | | | |
|---|---|---|---|---|---|
| Intensive dairy farming | 0.42 | * | 2,024 | = | 850.080 |
| Intensive pig farming | 0.37 | * | 8,297.25 | = | 3,069.983 |
| Broilers | 0.21 | * | 49,500 | = | 10,395.000 |
| Total | | | | | 14,315.063 |

6. Division of the available room per region by the extra production of phosphate results in the numbers of labour units intensive livestock farming that can be placed extra in these regions.

| | | |
|---|---|---|
| The northern region: | | |
| Present standard | 5,103,181 / 14,315.063 = | 356.490 |
| Stricter standard | 4,417,532 / 14,315.063 = | 308.593 |
| Strictest standard | 3,174,500 / 14,315.063 = | 221.759 |

These figures should be interpreted as follows: Under the present standard and a changed diet can be placed in the northern region:

| | |
|---|---|
| 0.42 * 356.490 = 150 | Intensive dairy farming |
| 0.37 * 356.490 = 132 | Intensive pig farming |
| 0.21 * 356.490 = 75 | Broilers |

And under the stricter standard:

| | |
|---|---|
| 0.42 * 308.593 = 130 | Intensive dairy farming |
| 0.37 * 308.593 = 114 | Intensive pig farming |
| 0.21 * 308.593 = 65 | Broilers |

And for the strictest standard:

| | |
|---|---|
| 0.42 * 221.759 = 93 | Intensive dairy farming |
| 0.37 * 221.759 = 82 | Intensive pig farming |
| 0.21 * 221.759 = 47 | Broilers |

7. For the eastern region are the calculations analogous. So, first of all the available room is divided by the extra production of phosphate:
   Present standard 8,110,375 / 14,315.063 = 566.562
   Stricter standard 7,504,749 / 14,315.063 = 524.255
   Strictest standard 5,371,093 / 14,315.063 = 375.206

   Also this time the division of the labour units in the different categories is taken into account. Under the present standard can be placed extra:
   0.42 * 566.562 = 238 Intensive dairy farming
   0.37 * 566.562 = 210 Intensive pig farming
   0.21 * 566.562 = 119 Broilers

   And under the stricter standard:
   0.42 * 524.255 = 220 Intensive dairy farming
   0.37 * 524.255 = 194 Intensive pig farming
   0.21 * 524.255 = 110 Broilers

   And for the strictest standard:
   0.42 * 375.206 = 158 Intensive dairy farming
   0.37 * 375.206 = 139 Intensive pig farming
   0.21 * 375.206 = 79 Broilers

8. Finally, the calculations for the western region are presented. First of all the available room is divided by the extra production of phosphate:
   3,051,220 / 14,315.063 = 213.148
   1,608,745 / 14,315.063 = 112.382
   879,838 / 14,315.063 = 61.462

   So, under the present standard in the western region there is still room for:
   0.42 * 213.148 = 90 Intensive dairy farming
   0.37 * 213.148 = 79 Intensive pig farming
   0.21 * 213.148 = 45 Broilers

   And under the stricter standard:
   0.42 * 112.382 = 47 Intensive dairy farming
   0.37 * 112.382 = 42 Intensive pig farming
   0.21 * 112.382 = 24 Broilers

   And for the strictest standard:
   0.42 * 61.462 = 26 Intensive dairy farming
   0.37 * 61.462 = 23 Intensive pig farming
   0.21 * 61.462 = 13 Broilers

*Computation 4: Available space for intensive livestock farming based on nitrate standards (with a change in diet).*

1. If, by changing the diet of the animals the production of nitrate per animal declines, does this not only apply to the numbers of animals that are eventually allowed to expand, but this also applies to the animals that are already in Groningen. So, the present production must also be corrected for this decline. This is done by multiplying the present production by an index. This index is the division of the expected extra production of nitrate with changed diet, by the

expected extra nitrate production without changed diet. This is completely analogous to the calculations for phosphate, in the situation with a changed diet, as shown in the previous appendix:

19,609.41 / 26,040 = 0.7530495

| | | | | | |
|---|---|---|---|---|---|
| The northern region | 951,000 | * | 0.7530495 | = | 716,150.07 |
| The eastern region | 1,766,000 | * | 0.753049 | = | 1,329,885.4 |
| The western region | 2,241,000 | * | 0.753049 | = | 1,687,583.4 |

2. To get the numbers of kilograms of nitrate that can be placed extra in the different regions, these corrected productions have to be subtracted from the available room, which has been calculated in the second appendix.

3. How many kilograms nitrate can be placed extra in the northern region:

| | | | | | |
|---|---|---|---|---|---|
| EC-guideline | 6,762,090 | - | 716,150.07 | = | 6,045,940 |
| Strictest standard | 2,616,928 | - | 716,150.07 | = | 1,900,779 |

The same calculation for the eastern region:

| | | | | | |
|---|---|---|---|---|---|
| EC-guideline | 11,607,090 | - | 1,329,885.4 | = | 10,277,205 |
| Strictest standard | 4,491,944 | - | 1,329,885.4 | = | 3,162,059 |

And for the western region:

| | | | |
|---|---|---|---|
| EC-guideline | 3,965,250 - 1,687,583.4 | = | 2,277,667 |
| Strictest standard | 1,534,551 - 1,687,583.4 | = | -153,031 |

4. An average labour unit intensive livestock farming has got: 50 cows, 1.725 pigs or 375.000 broilers. These animals produce each per year the following quantities of nitrate (in kilograms):

| | |
|---|---|
| Per cow | 124.00 |
| Per pig | 11.60 |
| Per broiler | 0.23 |

But, because of the changed diet, the nitrate production can be reduced by:

| | |
|---|---|
| Per cow | 25 percent |
| Per pig | 45 percent |
| Per broiler | 25 percent |

The nitrate production per animal will then be:

| | | | | | |
|---|---|---|---|---|---|
| Per cow | 0.75 | * | 124.00 | = | 93.000 |
| Per pig | 0.55 | * | 11.60 | = | 6.380 |
| Per broiler | 0.75 | * | 0.23 | = | 0.173 |

This means a production of nitrate for every type of farming (in kilograms per year):

| | | | | | |
|---|---|---|---|---|---|
| Intensive dairy farming | 50 | * | 93.000 | = | 4,650.0 |
| Intensive pig farming | 1,725 | * | 6.380 | = | 11,005.5 |
| Broilers | 375,000 | * | 0.173 | = | 64,875 |

5. If an increase of intensive live-stock farming with one labour unit occurs, it will be divided in these types:

| | |
|---|---|
| Intensive dairy farming | 42 percent = 0.42 |
| Intensive pig farming | 37 percent = 0.37 |

| | | | | | |
|---|---|---|---|---|---|
| Broilers | 21 percent = 0.21 | | | | |
| This expansion will lead to an increase of nitrate production (in kilograms per year) with: | | | | | |
| Intensive dairy farming | 0.42 | * | 4,650 | = | 1,953 |
| Intensive pig farming | 0.37 | * | 11,005.5 | = | 4,072 |
| Broilers | 0.21 | * | 64,687.5 | = | 13,584 |
| Total: | | | | | 19,609 |

6. Division of the available room per region by the extra production of nitrate results in the numbers of labour units intensive livestock farming that can be placed extra in these regions.

| | | |
|---|---|---|
| The northern region: | | |
| EC-guideline | 6,045,944.9 / 19,609 = | 308.325 |
| Strictest standard | 1,900,778.8 / 19,609 = | 96.934 |

Also this time the division of the labour units in the different categories is taken into account.
Under the EC-guidelines can be placed extra:

| | | |
|---|---|---|
| 0.42 * 308.325 = | 129 | Intensive dairy farming |
| 0.37 * 308.325 = | 114 | Intensive pig farming |
| 0.21 * 308.325 = | 65 | Broilers |

And for the strictest standard:

| | | |
|---|---|---|
| 0.42 * 96.934 = | 41 | Intensive dairy farming |
| 0.37 * 96.934 = | 36 | Intensive pig farming |
| 0.21 * 96,934 = | 20 | Broilers |

7. For the eastern region are the calculations analogous. So, first of all the available room is divided by the extra production of nitrate:

| | | |
|---|---|---|
| EC-guideline | 10,277,205 / 19,609 = | 524.107 |
| Strictest standard | 3,162,059 / 19,609 = | 161.255 |

Also this time the division of the labour units in the different categories is taken into account.

Under the EC-guidelines can be placed extra:

| | | |
|---|---|---|
| 0.42 * 524.107 = | 220 | Intensive dairy farming |
| 0.37 * 524.107 = | 194 | Intensive pig farming |
| 0.21 * 524.107 = | 110 | Broilers |

And for the strictest standard:

| | | |
|---|---|---|
| 0.42 * 161.255 = | 68 | Intensive dairy farming |
| 0.37 * 161.255 = | 60 | Intensive pig farming |
| 0.21 * 161.255 = | 34 | Broilers |

8. Finally, the calculations for the western region are presented.
First of all the available room is divided by the extra production of nitrate:

| | | | |
|---|---|---|---|
| EC-guideline | 2,277,667 / 19,609 | = | 116.154 |
| Strictest standard | -153,031 / 19,609 | = | -7.804 |

Under the EC-guidelines can be placed extra:

| | |
|---|---|
| 0.42 * -9.655 = | 49 Intensive dairy farming |
| 0.37 * -9.655 = | 43 Intensive pig farming |

| | |
|---|---|
| 0.21 * -9.655 = | 24 Broilers |

And for the strictest standard:

| | |
|---|---|
| 0.42 * -133.610 = | -3 Intensive dairy farming |
| 0.37 * -133.610 = | -3 Intensive pig farming |
| 0.21 * -133.610 = | -2 Broilers |

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