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and the Environment
Ministry of Health, Welfare and Sport

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A.E.J. Hooijboer et al.

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A.E.J. Hooijboer, RIVM
T.J. de Koeijer, LEI
A. van den Ham, LEI
L.J.M. Boumans, RIVM
H. Prins, LEI
C.H.G. Daatselaar, LEI
E. Buis, RIVM

Contact person:
Arno Hooijboer
Centre for Environmental Monitoring
arno.hooijboer@rivm.nl

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The Netherlands
www.rivm.nl

Abstract

Agricultural practices and water quality on farms registered for derogation in 2012

The EU Nitrates Directive obligates member states to limit the use of livestock manure to a maximum of 170 kg of nitrogen per hectare per year. Dutch farms cultivating at least 70 percent of their total area as grassland were in 2012 allowed to deviate from this requirement under certain conditions, and apply up to 250 kg of nitrogen per hectare (this partial exemption is referred to as 'derogation'). The Netherlands is obligated to monitor agricultural practices and water quality at 300 farms to which derogation has been granted, and to submit an annual report on the results to the EU. This study examines farms that registered for derogation in 2012, and concludes that the average nitrate concentration in groundwater on these farms decreased between 2007 and 2013. This report was prepared by the National Institute for Public Health and the Environment (RIVM) in collaboration with LEI Wageningen UR (LEI).

Agricultural practices
The report also shows that, on average, derogation farms in 2012 used approx. 11 kg less nitrogen in livestock manure than the prescribed maximum of 250 kg of nitrogen per hectare. The quantity of nitrogen that can potentially leach into the groundwater in the form of nitrate is partly determined by the nitrogen soil surplus. This surplus is defined as the difference between nitrogen input (e.g. in the form of fertilisers) and nitrogen output (e.g. via milk). On average, the nitrogen soil surplus has not changed substantially between 2006 and 2012.

Groundwater quality
In 2012, the average groundwater nitrate concentration on derogation farms in the Sand Region amounted to 36 milligrammes per litre (mg/l) and was therefore below the nitrate standard of 50 mg/l. On average, farms in the Clay and Peat Regions had even lower nitrate concentrations (10 and 4 mg/l, respectively). With an average groundwater nitrate concentration of 55 mg/l, only derogation farms in the Loess Region exceed the standard. The difference between the regions is mainly caused by a higher percentage of soils prone to nitrogen leaching in the Sand and Loess Regions. Less denitrification occurs on these soils, and more nitrate can therefore leach into the groundwater.

Keywords:
Derogation, agricultural practice, manure, Nitrates Directive, water quality

Publiekssamenvatting

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie in 2012

De Europese Nitraatrichtlijn verplicht lidstaten om het gebruik van dierlijke mest te beperken tot 170 kg stikstof per hectare. Landbouwbedrijven in Nederland met ten minste 70% grasland mochten in 2012 onder bepaalde voorwaarden van deze norm afwijken en 250 kilogram per hectare gebruiken (derogatie). Nederland is verplicht om op 300 bedrijven die derogatie gebruiken, de bedrijfsvoering en waterkwaliteit te meten en deze resultaten jaarlijks aan de EU te rapporteren. Uit de rapportage over de bedrijven die in 2012 voor derogatie zijn aangemeld, opgesteld door het RIVM met LEI Wageningen UR, blijkt dat de nitraatconcentratie in het grondwater tussen 2007 en 2013 is gedaald.

Bedrijfsvoering
Uit de rapportage blijkt ook dat het stikstofgebruik uit dierlijke mest op de derogatiebedrijven in 2012 gemiddeld circa 11 kilo lager was dan de maximaal toegestane 250 kilo stikstof per hectare. De hoeveelheid stikstof die als nitraat kan uitspoelen naar het grondwater, wordt onder andere bepaald door het stikstofbodemoverschot. Dit is het verschil tussen de aanvoer van stikstof (zoals meststoffen) en de afvoer ervan (waaronder via melk). Het stikstofbodemoverschot, gemiddeld over heel Nederland, is niet duidelijk veranderd tussen 2006 en 2012.

Grondwaterkwaliteit
In 2012 lag de nitraatconcentratie in het grondwater in de Zandregio met gemiddeld 36 milligram per liter (mg/l) onder de nitraatnorm van 50 mg/l. Bedrijven in de Kleiregio en de Veenregio hadden gemiddeld een lagere nitraatconcentratie (10 en 4 mg/l). Alleen de derogatiebedrijven in de Lössregio bevonden zich gemiddeld met 55 mg/l boven de norm. Het verschil tussen de regio's wordt vooral veroorzaakt door een hoger percentage droge gronden in de Zand- en Lössregio; dit zijn gronden waar nitraat in mindere mate in de bodem wordt afgebroken en daardoor kan uitspoelen naar het grondwater.

Trefwoorden:
derogatiebeschikking, landbouwpraktijk, mest, Nitraatrichtlijn, waterkwaliteit

Preface

This report provides an overview of agricultural practices in 2012 on all farms that registered for derogation in the derogation monitoring network. The agricultural practice data include data on fertiliser use and actual nutrient surpluses. Information is also provided about the results of water quality monitoring conducted in 2012 and 2013 on farms in the derogation monitoring network.

This report was commissioned by the Dutch Ministry of Economic Affairs, and prepared by the National Institute for Public Health and the Environment (RIVM) in collaboration with LEI Wageningen UR (LEI). LEI is responsible for the information about agricultural practices, while RIVM is responsible for the water quality data. RIVM also served as the official secretary for this project.

The monitoring network covers 300 farms. The farms in the derogation monitoring network were either already participating in the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM), or were recruited and sampled during sampling campaigns.

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Arno Hooijboer, Tanja de Koeijer, Aart van den Ham, Leo Boumans, Henri Prins, Co Daatselaar and Eke Buis

26 June 2014

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Summary

Introduction
The EU Nitrates Directive obligates member states to limit the use of nitrogen in livestock manure to a maximum of 170 kg of nitrogen per hectare per year. The Netherlands has requested the European Commission to issue an exemption from this obligation (this exemption is referred to as 'derogation' throughout this report). Dutch grassland farms cultivating at least 70 percent of their total area as grassland were in 2012 allowed to apply up to 250 kg of nitrogen per hectare in the form of manure from grazing livestock. The conditions attached to this exemption arrangement include an obligation for the Dutch government to set up a monitoring network comprising 300 farms that have registered for derogation ('derogation farms'), and to submit annual reports to the European Commission.

The derogation monitoring network was set up by expanding the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM) of RIVM and LEI. A stratified random sampling method was used to select 300 farms, distributed as evenly as possible according to soil type (sand, loess, clay and peat), farm type (dairy farms and other grassland farms), and economic size. Of these 300 farms, 295 actually participated in the derogation scheme in 2012.

Agricultural practices in 2012
In 2012, the farms in the derogation monitoring network used an average of 239 kg of nitrogen from livestock manure per hectare of cultivated land. This is 11 kg less than the nitrogen application standard for livestock manure (250 kg per hectare). The total use of nitrogen (in the form of inorganic fertilisers and plant-available nitrogen from livestock manure) was 14 kg less than the total nitrogen application standard (257 kg per hectare on average). Phosphate use was slightly below the average phosphate application standard for farms in the derogation monitoring network (89 kg per hectare), taking account of the phosphate status of the soil.

The average nitrogen surplus on the soil surface balance in 2012 was calculated at 188 kg per hectare. This nitrogen surplus decreased in the following order: Peat > Clay > Sand > Loess. The phosphate surplus on the soil surface balance amounted to 9 kg of P_2O_5 per hectare on average.

Agricultural practices during the 2007-2012 period
Milk production per farm, per hectare and per cow all increased during the 2007-2012 period. The area of cultivated land per farm also increased, but to a lesser extent than the milk production per farm. This indicates a slow, gradual increase in scale and intensification, resulting in higher milk production per cow and per hectare of fodder crop. Despite the increase in milk production per hectare of fodder crop, nitrogen production in livestock manure per hectare decreased, particularly after 2010.

The proportion of grassland has remained virtually stable, while the proportion of farms with grazing dairy cows slowly declined until 2011. The decrease in grazing in the September-October period was greater than the decrease in grazing throughout the entire May-October grazing period. The percentage of dairy farms with grazing animals in 2012 was comparable to the relevant percentage in 2011.

The percentage of farms with grazing animals and intensive livestock decreased. As a result, the average livestock density per hectare measured in Phosphate Livestock Units (LSUs) also decreased.

In 2012, the quantity of nitrogen produced in livestock manure was 14 kg per hectare lower than in 2011. The use of nitrogen in livestock manure remained virtually unchanged in the 2006-2012 period. The use of inorganic fertilisers also remained virtually constant. As a result of the higher statutory availability coefficient for nitrogen in livestock manure, the total use of plant-available nitrogen is increasing, but still remains below the total application standard for nitrogen. In 2012, the total release of plant-available nitrogen was a few kilogrammes below the level of 2011. This was caused by lower production of nitrogen in the form of manure per farm.

The application standard for phosphate decreased between 2006 and 2012. This was associated with a decrease in the use of phosphate, particularly in the form of inorganic phosphate-containing fertilisers.

The grass and silage maize crop yields (expressed in tonnes of dry matter per hectare) increased during the 2006-2012 period. The yield measured in kilogrammes of phosphate per hectare also rose. The grass yield measured in kilogrammes of nitrogen per hectare decreased between 2006 and 2012. This was caused by lower nitrogen contents in the grass in 2012 compared to previous years. As a result, the nitrogen yields in 2012 were lower than in previous years. The same applied to silage maize. In 2013, the nitrogen contents in grass returned to a level comparable to that of the 2006-2011 period (Netherlands Laboratory for Soil and Crop Research, 2014).

The nitrogen surpluses on the soil surface balance fluctuated somewhat from year to year, but no overall increase or decrease took place during the 2006-2012 period. In 2012, both the nitrogen input (via feed products) and the nitrogen output (via animals and livestock manure) decreased compared to 2011. The phosphate soil surplus did decrease between 2006 and 2012, however. In 2012, the phosphate input (via feed products) and the phosphate output (via animals and manure) decreased as well. The decrease in the use of inorganic phosphate-containing fertilisers mainly took place in the 2006-2010 period. Both the nitrogen soil surpluses and the phosphate soil surpluses differ significantly between farms.

Water quality in 2012
At 36 mg/l, the average nitrate concentration in groundwater in the Sand Region was below the nitrate standard of 50 mg/l. At 55 mg/l, the average nitrate concentration on farms in the Loess Region exceeded the standard. Nitrate concentrations in the Clay Region (10 mg/l) and the Peat Region (4 mg/l) were lower. In the Sand Region, nitrate concentrations were below the nitrate standard on 74 percent of all farms. In the Loess Region, this was the case on 47 percent of all farms. The percentage of farms with below-standard average nitrate concentrations was 100 percent in both the Clay Region and the Peat Region. The nitrate and nitrogen concentrations measured in ditch water were lower than the concentrations measured in water leaching from the root zone.

The highest phosphor concentrations in water leaching from the root zone were measured in the Peat Region (0.42 mg P/l), followed by the Clay Region (0.34 mg P/l). The average phosphorus concentration in the Sand Region was 0.09 mg P/l, and below the detection threshold in the Loess Region.

Water quality in the 2007-2013 period
In 2013, the nitrate concentrations measured in water leaching from the root zone in the Sand, Clay and Peat Regions were lower than the average levels in previous years. This was not the case in the Loess Region. Concentrations in the Sand, Clay and Peat Regions decreased between 2007 and 2013. The three lowest nitrate concentrations were measured in the past three years. The decrease in nitrate concentrations was also observed in ditch water.

During the measurement period, phosphorus concentrations decreased in the Clay Region and increased in the Sand Region. During the measurement period, no trend change could be observed in the phosphorus concentrations in the other regions.

Relationship between agricultural practices and water quality
The nitrogen soil surpluses did not decrease or increase during the 2006-2012 period. However, the nitrate concentrations in groundwater did decrease during this period. Possible causes of this decrease may include after-effects of higher soil surpluses in the past or a decrease in grazing.

As a result of a decrease in the use of inorganic fertilisers in the 2006-2012 period, the phosphate surplus on the soil surface balance fell from 26 kg to 9 kg per hectare. During the measurement period, phosphorus concentrations in the Clay Region also decreased (possibly as a result of this).

1 Introduction

1.1 Background

The EU Nitrates Directive obligates member states to limit the use of nitrogen in livestock manure to a maximum of 170 kg of nitrogen per hectare per year (EU, 1991). A member state can request the European Commission for exemption from this obligation under certain conditions (this exemption is referred to as 'derogation' throughout this report). In December 2005, the European Commission issued the Netherlands with a derogation decision for the 2006-2009 period (EU, 2005). Under this decision, grassland farms cultivating at least 70 percent of their total area as grassland are allowed to apply on their total area up to 250 kg of nitrogen per hectare in the form of livestock manure originating from grazing livestock. In February 2010, the derogation decision was extended until the end of December 2013 (EU, 2010). The Dutch government is obligated to collect various data about the effects of the derogation scheme, and to report these annually to the European Commission. This report has been prepared to fulfil this obligation under the derogation decision.

1.2 Fulfilment of obligations, approach

The present report together with the RVO.nl report (RVO.nl, 2014) fulfil the following obligations under the derogation decision (2005):

Article 8 Monitoring

8.1 *Maps showing the percentage of grassland farms, percentage of livestock and percentage of agricultural land covered by individual derogation in each municipality, shall be drawn by the competent authority and shall be updated every year. Those maps shall be submitted to the Commission annually and for the first time in the second quarter of 2006.*

This obligation is fulfilled in RVO.nl *et al.* (2014).

8.2 *A monitoring network for sampling of soil water, streams and shallow groundwater shall be established and maintained as derogation monitoring sites. The monitoring network, corresponding to at least 300 farms benefiting from individual derogations, shall be representative of each soil type (clay, peat, sandy and sandy loessial soils), fertilisation practices and crop rotation. The composition of the monitoring network shall not be modified during the period of applicability of this Decision.*

Chapter 2 describes the set-up of the derogation monitoring network.

8.3 *Survey and continuous nutrient analysis shall provide data on local land use, crop rotations and agricultural practices on farms benefiting from individual derogations. Those data can be used for model-based calculations of the magnitude of nitrate leaching and phosphorus losses from fields where up to 250 kg nitrogen per hectare per year in manure from grazing livestock is applied.*

Section 3.1 (situation) and section 4.1 (trends) summarise the results of the 300 farms that participate in the derogation monitoring network. Appendix 5 presents the data of all derogation farms in the Netherlands, and discusses the differences between the two sets of results arising from a difference in approach.

8.4 Shallow groundwater, soil water, drainage water and streams in farms belonging to the monitoring network shall provide data on nitrate and phosphorus concentration in water leaving the root zone and entering the groundwater and surface water system.

Section 3.2 (situation) and section 4.2 (trends) provide data on the quality of ditch water and water leaching from the root zone on the 300 farms that participate in the derogation monitoring network.

8.5 A reinforced water monitoring shall address agricultural catchments in sandy soils.

Of the 300 farms in the planned sample, 160 farms are located in the Sand Region (also see section 2.4).

Article 9 Controls

9.1 The competent national authority shall carry out administrative controls in respect of all farms benefiting from an individual derogation for the assessment of compliance with the maximum amount of 250 kg nitrogen per hectare per year from grazing livestock manure, with total nitrogen and phosphate application standards and conditions on land use.

9.2 A programme of inspections shall be established based on risk analysis, results of controls of the previous years and results of general random controls of legislation implementing Directive 91/676/EEC. Specific inspections shall address at least 5% of farms benefiting from an individual derogation with regard to land use, livestock number and manure production. Field inspections shall be carried out in at least 3% of farms in respect to the conditions set out in Article 5 and 6.

The results of these controls are included in RVO.nl *et al.* (2014).

Article 10 Reporting

10.1 The competent authority shall submit the results of the monitoring, every year, to the Commission, with a concise report on evaluation practice (controls at farm level, including information on non compliant farms based on results of administrative and field inspections) and water quality evolution (based on root zone leaching monitoring, surface/groundwater quality and model-based calculations). The report shall be transmitted to the Commission annually in the second quarter of the year following the year of activity. (Additional provision in the extension of the derogation decision, EU, 2010)

The present report is the report referred to in the above article. Details of controls and instances of non-compliance are presented in RVO.nl *et al.* (2014).

10.2 In addition to the data referred to in paragraph 1 the report shall include the following:

- *(a) data related to fertilisation in all farms which benefit from an individual derogation;*
- *(b) trends in livestock numbers for each livestock category in the Netherlands and in derogation farms;*
- *(c) trends in national manure production as far as nitrogen and phosphate in manure are concerned;*
- *(d) a summary of the results of controls related to excretion coefficients for pig and poultry manure at country level.*

Section 3.1 (situation) and section 4.1 (trends) summarise the agricultural practice results of the 300 farms that participate in the derogation monitoring network. Appendix 5 presents the data of all derogation farms in the Netherlands, and discusses the differences between the two sets of results arising from a difference in approach. The obligation referred to in Article 10(2)(d) is fulfilled in RVO.nl *et al.* (2014).

10.3 The results thus obtained will be taken into consideration by the Commission with regard to an eventual new request for derogation by the Dutch authorities.

10.4 In order to provide elements regarding management in grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the competent authority and submitted to the Commission.

Section 3.1.3 provides the yields for grass and silage maize per hectare for the different soil regions on the 300 derogation farms. Section 3.1.3 provides the use of nitrogen from manure and fertilizer for crop type and soil region

1.3 Previously published reports and contents of this report

This is the eighth annual report setting out the results of the derogation monitoring network. It contains data on fertilisation, crop yields, nutrient surpluses and water quality.

The first report (Fraters *et al.*, 2007b) was limited to a description of the derogation monitoring network, the progress made in 2006, and the design and content of the reports for the years 2008 to 2010 inclusive. The derogation monitoring network results have been published in the subsequent reports (Fraters *et al.*, 2008; Zwart *et al.*, 2009, 2010 and 2011; Buis *et al.*, 2012; Hooijboer *et al.*, 2013). Once results for multiple measurement years became available, the reports devoted increasing attention to the consideration of trends in agricultural practices and water quality.

Chapter 2 describes the design and implementation of the derogation monitoring network. It also details the agricultural characteristics of the participating farms (section 2.6). Section 2.7 describes the water quality sampling method, and the soil characteristics of the farms where water quality samples were taken.

Chapter 3 presents and discusses the measurement results of the agricultural practice and water quality monitoring for 2012. This chapter also contains the provisional water quality monitoring results for 2013 (see section 3.2.3).

Chapter 4 describes developments related to agricultural practices and water quality, including a discussion of trend-based changes since the start of the derogation scheme, and a statistical analysis of the extent to which agricultural practice year 2012 differed from previous years. In addition, an assessment is provided concerning the effects of agricultural practices on water quality.

2 Design of the derogation monitoring network

2.1 Introduction

The design of the derogation monitoring network must satisfy the requirements of the European Commission, as stipulated in the derogation decision of December 2005 and the extension of the derogation granted in 2010 (refer to section 1.3). Previous reports provided extensive details about the composition of the sample and the choices this entailed (Fraters and Boumans, 2005; Fraters *et al.*, 2007b).

During negotiations with the European Commission, it was agreed that the design of this monitoring network would tie in with the existing national network for monitoring the effectiveness of minerals policy, the Minerals Policy Monitoring Programme (LMM). Water quality and agricultural practices at farms selected for this purpose have been monitored under this programme since 1992 (Fraters and Boumans, 2005). Additionally, it was agreed that all LMM participants that satisfy the relevant conditions would be regarded as participants in the derogation monitoring network.

All agricultural practice data relevant to the derogation scheme were registered in accordance with the FADN system (Poppe, 2004). Appendix 2 provides a description of the monitoring of the agricultural characteristics and the calculation methods for fertiliser use and nutrient surpluses. Water sampling on the farms was carried out in accordance with the standard LMM procedures (Fraters *et al.*, 2004). This sampling method is explained in Appendix 3.

The set-up of the derogation monitoring network and the reporting of results are based on the division of the Netherlands into regions as used in the action programmes for the Nitrates Directive (EU, 1991). Four regions are distinguished: the Sand Region, the Loess Region, the Clay Region and the Peat Region. The acreage of agricultural land in the Sand Region accounts for about 47 percent of the approx. 1.85 million hectares of agricultural land in the Netherlands (Statistics Netherlands Agricultural Census, data processed by LEI, 2012). The acreage of agricultural land in the Loess Region accounts for approx. 1.5 percent, in the Clay Region for approx. 41 percent, and in the Peat Region for approx. 10.5 percent of all agricultural land.

2.2 Change of method in 2013 and 2014

With effect from measurement year 2011 (Hooijboer *et al.*, 2013), there have been some changes to the boundaries of the four regions that are reported on. As of measurement year 2011, the regional boundaries have been adjusted with retroactive effect for all years surveyed, including a recalculation of historical data sets. Another consequence of the new regional boundaries is that a number of farms are no longer included in the water quality report, because the samples at these farms were taken outside the period applicable to the new region (see section 2.4.2). Due to the new regional boundaries, minor differences have arisen between the trend data in the present reports and the trend data in the reports published prior to 2013. Hooijboer *et al.* (2013) explain the effects that this has on water quality and soil surpluses during the 2006-2012 period.

The same applies to the FADN calculation system used by LEI to determine soil surpluses. With effect from measurement year 2011, the calculation system was changed compared to previous years. An explanation of this adjustment is provided in Hooijboer *et al.* (2013). It turned out that the present report required a correction of the nitrogen content in the roughage stocks on clay soils in 2007. As a result, the nitrogen soil surpluses in 2007 and 2008 were recalculated. These surpluses therefore deviate from the surpluses presented in Hooijboer *et al.* (2013) for both years.

Other differences in nitrogen soil surpluses arose as a result of minor adjustments at farm level or because some farms dropped out. As a result, differences in nitrogen soil surpluses of more than 10 kg of nitrogen per hectare per year may arise for small groups of farms like those in the Peat and Loess Regions.

2.3 Statistical method used to determine deviations and trends

Determining deviations in the measurement year under consideration
The comparison aims to establish if there is a significant difference between the measurement year and the average for the preceding years. The significance was determined using the Restricted Maximum Likelihood procedure (REML method). The REML method is suitable for unbalanced data sets and therefore takes account of farms which 'drop out' and are replaced. The agricultural practice data were processed using the REML method available as part of the 'linear mixed effects models procedure' (MIXED method) in IBM SPSS Statistics (version 20). The water quality data were processed using the REML method in GenStat (14th edition; VSN International Ltd.).

The calculations were based on unweighted annual farm averages, i.e. the data were not corrected for farm acreage, size, etc. All available annual farm averages were divided into two groups, with Group 1 comprising all the averages for the measurement year concerned, and Group 2 comprising all averages for the preceding years. The difference between Group 1 and Group 2 was then estimated as a so-called 'fixed effect', taking into account the fact that some data are not derived from the same farms ('random effect'). A discussion of fixed and random effects may be found in standard statistical manuals on variance analysis, e.g. Kleinbaum *et al.* (1997) and Payne (2000). Welham *et al.* (2004) explain how to produce estimations with such models.

If the results for the most recent measurement year deviate significantly from the average of the preceding years ($p < 0.05$), the direction of the deviation compared to previous years is indicated by a plus sign (+) or minus sign (-). If there is no significant difference ($p > 0.05$), this is indicated by the 'approximately equal' sign (≈). These symbols may be found in the 'Difference' column in the overview tables (e.g. Appendix 4, Table A4.1B). The main text of this report only makes mention of differences if they are significant.

Determination of trends
The data were also analysed to identify any trends during the measurement period. The REML method with annual groups was used for this purpose as well. Only significant trend changes ($p < 0.05$) will be considered.

2.4 Water quality and agricultural practices

The water quality levels measured in any year partly reflect agricultural practices in the year preceding the water quality monitoring and agricultural practices in previous years. The extent to which agricultural practices in previous years affect the water quality measurements depends on various factors, including (fluctuations in the) precipitation surplus during that year and local hydrological conditions. In the High Netherlands, it is assumed that agricultural practices affect water quality at least one year later. In the Low Netherlands, the impact of agricultural practices on water quality is quicker to materialise. This difference in hydrological conditions (rate of leaching) also explains the different sampling methods and sampling periods employed in the Low and the High Netherlands (see Appendix 3).

In the Low Netherlands, water quality is determined in the winter following the year in which the agricultural practices were determined. The 'Low Netherlands' comprises the Clay and Peat Regions, as well as those parts of the Sand Region that are drained by means of ditches, possibly in combination with drainage pipes or surface drainage. The 'High Netherlands' comprises the other parts of the Sand Region, and the Loess Region. In the Sand Region, groundwater is sampled in the summer following the year in which agricultural practices were determined. In the Loess Region, soil moisture samples are taken in the autumn following the year in which agricultural practices were determined (see Appendix 3).

This means that water quality samples for measurement year 2012 can be related to agricultural practices in 2011 (see Table 2.1). Water quality samples for measurement year 2012 were taken during the winter of 2011/2012 in the Low Netherlands, and during the summer and autumn of 2012 in the High Netherlands.

The present report includes water quality sampling results for measurement year 2013, which can be related to agricultural practices in 2012 (see Table 2.1). These water samples were taken in the winter of 2012-2013 in the Low Netherlands, and in the summer of 2013 in the High Netherlands. The results for the Loess Region from sampling carried out in the autumn of 2013 are not yet available, and the other data are regarded as provisional because not all the required quality controls have been completed at this time. The definitive figures will be reported in 2015, at which time the 2013 data for the Loess Region will also be available and finalised.

Table 2.1 Overview of data collection periods for the presented monitoring results on agricultural practices and water quality

Report	Agricultural practices	Water quality[2]		
		Clay and Peat Regions	Sand Region	Loess Region
Hooijboer *et al.*, 2013	2011	2010/2011 final, 2011/2012 provisional	2011 final, 2012 provisional	2011/2012 final 2012/2013 not yet available
Hooijboer *et al.*, 2014[1]	2012	2011/2012 final, 2012/2013 provisional	2012 final, 2013 provisional	2012/2013 final 2013/2014 not yet available

[1] Present report

[2] The provisional figures can be related to the agricultural practice data presented in the same report.

The definitive figures can be related to the agricultural practice data presented in the previous report.

2.5 Number of farms in 2012

2.5.1 *Number of farms where agricultural practices were determined*

Although the derogation monitoring network is a permanent network, a number of farms 'drop out' every year because they are no longer participating in the LMM programme. It is also possible that agricultural practices could not be reported due to incomplete data on nutrient flows. Incomplete nutrient flow data may be caused by the presence on the farm of animals owned by other parties, so that data on the input and output of feedstuffs, animals and manure is by definition incomplete. In addition, other administrative errors may have been made when registering inputs and/or outputs. However, water quality samples have been taken in these cases.

Agricultural practices were successfully established at 298 of the 300 planned farms. Of these 298 farms, 295 actually participated in the derogation scheme. Seventeen farms that participated in the derogation monitoring network in 2011 have since dropped out. These farms have therefore been replaced.

Table 2.2 Planned and actual number of analysed dairy and other grassland farms per region in 2012 (agricultural practices)

Farm type	*Planned/actual*	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Dairy farms	Planned[1]	140	17	52	52	261
	Actual - Of which processed by LEI[2]	134	17	60	52	263[3]
	- Of which participating in the derogation scheme	134	17	60	52	263[3]
	- Of which submitted complete nutrient flow data	133	17	59	52	261
Other grassland farms	Planned[1]	20	3	8	8	39
	Actual - Of which processed by LEI[2]	21	2	7	5	35
	- Of which participating in the derogation scheme	18	2	7	5	32
	- Of which submitted complete nutrient flow data	11	2	4	3	20
Total	Planned[1]	160	20	60	60	300
	Actual - Of which processed by LEI[2]	155	19	67	57	298
	- Of which participating in the derogation scheme	152	19	67	57	295
	- Of which submitted complete nutrient flow data	144	19	63	55	281

[1] As determined based on old regional boundaries

[2] As determined based on new regional boundaries

[3] The actual sample differs from the planned sample due to changes in regional boundaries and developments on the farms

The various sections of this report describe agricultural practices based on the following numbers of farms:

- The description of general farm characteristics (section 2.5) concerns all farms that could be fully processed in FADN in 2012, and that participated in the derogation scheme (295 farms).
- The description of agricultural practices in 2012 (section 3.1) concerns all farms for which a full picture of nutrient flows could be obtained from FADN data (281 farms).
- The comparison of agricultural practices in the 2006-2012 period (section 4.1) concerns all farms that participated in the derogation monitoring network in the respective years. This number varies from year to year (see Appendix 4, Table A4.2A).

2.5.2 Number of farms where water quality was sampled

In 2012, water quality was sampled on 299 farms (see Table 2.3). Of these 299 farms, 283 participated in the derogation monitoring network in 2012. The difference of sixteen farms is caused by the fact that no samples could be taken at new farms in 2012 due to changes in the derogation monitoring network. The sixteen farms that have dropped out have been used to determine trends in water quality, however. Of the remaining 283 farms, a further eleven farms dropped out because they could not be included in the reports after the new regional boundaries were introduced. Samples at these farms were previously taken in summer, and the farms were then reassigned to a region where samples are taken only in winter (i.e. the Clay and Peat Regions). Furthermore, three farms did not qualify for participation or did not actually participate in the derogation scheme. It is unknown if two farms qualified for participation or actually participated in the derogation scheme, since these farms are not included in FADN. The water quality sampling results of the remaining 267 sampled farms are presented in this report.

Table 2.3 Planned and actual number of analysed dairy and other grassland farms per region in 2012 (water quality)

Farm type	*Planned/actual*	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Dairy farms	Planned[1]	140	17	52	52	261
	Actual					
	- Sampled[2]	133	18	63	49	263
	- Derogation monitoring network 2012[3]	124	17	61	48	250
	- Included after changes to regional boundaries	124	17	52	46	239
	- Participated in derogation scheme	122	17	51	46	236
Other grassland farms	Planned[1]	20	3	8	8	39
	Actual					
	- Sampled[2]	21	2	8	5	36
	- Derogation monitoring network 2012[3]	19	2	7	5	33
	- Included after changes to regional boundaries	19	2	7	5	33
	- Participated in derogation scheme	17	2	7	5	31
Total	Planned[1]	160	20	60	60	300
	- Sampled[2]	153	19	71	54	299
	- Derogation monitoring network 2012[3]	143	19	68	53	283
	- Included after changes to regional boundaries	143	19	59	51	272
	- Participated in derogation scheme	139	19	58	51	267

[1] As determined based on old regional boundaries

[2] As determined based on new regional boundaries

[3] Samples are often taken at farms before the composition of the monitoring network is known (i.e. after certain farms have dropped out). The farms that have dropped out are used to determine trends, however.

This report details the water quality on the following numbers of farms:

- The description of the water quality results for measurement year 2012 (section 3.2) concerns all farms where water quality samples were taken in 2012 and that qualified for participation in the derogation scheme in 2012 (267 farms).
- The description of the water quality results for measurement year 2013 (section 3.2) concerns all farms participating in the derogation monitoring network in 2012 (excluding farms in the Loess Region) where water quality samples were taken in measurement year 2013 (280 farms). In measurement year 2013, the sampling procedure was adjusted to the new regional boundaries to ensure that farms switching regions would no longer 'drop out'.
- The analysis of water quality levels during the 2007-2013 period (section 4.2) concerns all farms that participated in the derogation monitoring network in the agricultural practice year preceding the relevant

measurement year, and that were entitled to derogation in that previous year. This number varies from year to year (see Table 2.4).

Table 2.4 Number of farms per year used to determine water quality trends (the farms qualified for participation in the derogation scheme prior to the year when samples were taken)

Year	Number of farms
2007	278
2008	279
2009	280
2010	279
2011	281
2012	277
2013	276 (excluding farms in Loess Region)*

* In 2013, the sampling procedure was adjusted to the new regional boundaries to ensure that farms switching regions would no longer 'drop out'.

Depending on the soil type region, water leaching from the root zone (groundwater, drain water or soil moisture) and/or ditch water is sampled (see Table 2.5).

Table 2.5 Number of sampled and reported farms[1] per sub-programme and per region in 2012 and 2013, and sampling frequency of leaching water (LW) and ditch water (DW) (the target sampling frequency is stated in parentheses)

Year		*Sand*	*Loess*	*Clay*	*Peat*	*Total*
2012	Number of farms	139	19	58	51	267
	Number of farms – Leaching water	138	19	58	51	266
	Number of farms – Ditch water	34	-	57	50	141
	LW sampling frequency	1.0 (1)	1.0 (1)	3.0 (2-4)[1]	1.0 (1)	
	DW sampling frequency	4.0 (4)	-	4.0 (4)	4.3 (4-5)	
2013	Number of farms	155	-*	68	57	280
	Number of farms – Leaching water	154	-*	68	57	279
	Number of farms – Ditch water	35	-	67	56	158
	LW sampling frequency	1.0 (1)	-*	3.4 (2-4)	1.0 (1)	
	DW sampling frequency	3.8 (4)	-	4.0 (4)	4.1 (4-5)	

[1] In the Clay Region, groundwater is sampled up to two times and drainage water up to four times, depending on the type of farm. Therefore, the average total number of samples will always be between two and four, depending on the proportion of farms with groundwater sampling versus farms with drainage water sampling.

* In the Loess Region, samples were taken at twenty derogation farms during the autumn of 2013. These sample results were not yet available when this report was compiled.

2.6 Representativeness of the sample of farms

In 2012, 295 farms are known to have registered for derogation. These farms had a combined total acreage of 16,337 hectares, accounting for 2.0 percent of all agricultural land on grassland farms in the Netherlands, see Table 2.6). The sample represents 85 percent of the farms and 96 percent of the acreage of all farms that registered for derogation in 2012 and satisfied the LMM selection criteria (refer to Appendix 1). Farms not included in the sample population and that did register for derogation are mainly other grassland farms with a size of less than 25,000 Standard Output (SO) units.

Furthermore, it is noteworthy that in all regions the proportion of sampled to total acreage is greater on dairy farms than on other grassland farms. During the selection and recruitment process, the required number of farms to be sampled for each farm type is derived from the share in the total acreage of cultivated land. On average, the other grassland farms included are slightly smaller than the dairy farms in terms of their acreage of cultivated land.

The Loess Region is relatively small and therefore does not have many derogation farms in the sample population. Consequently, a relatively large proportion of farms (15.7 percent) is included in the monitoring network.

Table 2.6 Area of cultivated land (in hectares) included in the derogation monitoring network compared to the total area of cultivated land on derogation farms in 2012 in the sample population, according to the 2012 Agricultural Census

		Sample population[1]	*Derogation monitoring network*	
Region	*Farm type*	*Area (hectares)*	*Area (hectares)*	*Percentage of acreage of total sample population*
Sand	Dairy farms	339,113	7,261	2.1%
	Other grassland farms	49,490	603	1.2%
	Total	388,603	7,864	2.0%
Loess	Dairy farms	4,617	776	16.8%
	Other grassland farms	688	58	8.4%
	Total	5,305	834	15.7%
Clay	Dairy farms	232,148	3,889	1.7%
	Other grassland farms	28,752	152	0.5%
	Total	260,899	4,041	1.5%
Peat	Dairy farms	134,100	3,403	2.5%
	Other grassland farms	13,242	195	1.5%
	Total	147,343	3,598	2.4%
All types	Dairy farms	709,978	15,329	2.2%
	Other grassland farms	92,172	1,008	1.1%
	Total	802,150	16,337	2.0%

[1] Estimate based on the 2012 Agricultural Census performed by Statistics Netherlands, data processed by LEI. Refer to Appendix 1 for further information on how the sample population was defined.

2.7 Description of farms in the sample

The 295 farms which are known to have registered for derogation in 2012 had an average of 55 hectares of cultivated land, of which 83 percent was comprised of grassland. The average livestock density was 2.27 Phosphate Livestock Units (LSUs) per hectare (see Table 2.7). Farm data derived from the 2012 Agricultural Census have been included for purposes of comparison, in so far as these farms were included in the sample population (Appendix 1).

From the comparison of the structural characteristics of the population of sampled farms and the Agricultural Census data (Table 2.8), we can conclude that the population of sampled farms is representative of the Agricultural Census sample population, despite some minor differences.

Table 2.7 Overview of a number of general characteristics in 2012 of farms participating in the derogation monitoring network (DMN), compared to average values for the Agricultural Census (AC) sample population

Farm characteristic[1]	*Population*	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Number of farms in DMN	DMN	152	19	67	57	295
Grassland area (hectares)	DMN	40	32	50	56	45
	AC	33	31	45	43	38
Area used to cultivate silage maize (hectares)	DMN	10.4	9.6	8.2	6.8	9.2
	AC	7.8	7.7	5.2	3.7	6.4
Other arable land (hectares)	DMN	1.0	2.1	1.8	0.1	1.1
	AC	0.5	1.6	1.0	0.3	0.6
Total area of cultivated land (hectares)	DMN	52	44	60	63	55
	AC	41	40	51	47	45
Percentage of grassland	DMN	79	74	86	91	83
	AC	81	78	89	94	85
Natural habitat (hectares)	DMN	1.3	2.1	1.8	1.1	1.4
	AC	0.9	1.8	1.3	1.2	1.1
Grazing livestock density (Phosphate Livestock Units per hectare)[2]	DMN	2.31	2.41	2.24	2.14	2.27
	AC	2.27	2.24	2.04	1.98	2.15
Percentage of farms with intensive livestock (%)	DMN	7	11	1	11	6
	AC	10	3	5	5	8
Specification of livestock density on farms participating in derogation monitoring network (Phosphate Livestock Units per hectare)[1]						
Dairy cattle (including young livestock)	DMN	2.22	2.20	2.09	2.03	2.16
Other grazing livestock	DMN	0.08	0.21	0.16	0.11	0.11
Intensive livestock (total)	DMN	0.63	0.02	0.00	0.20	0.37
All animals (total)	DMN	2.94	2.43	2.25	2.34	2.63

Source: FADN and Statistics Netherlands Agricultural Census 2012 (data processed by LEI).

[1] Surface areas are expressed in hectares of cultivated land; natural habitats have not been included.

[2] Phosphate Livestock Unit (LSU) is a standard used to compare numbers of animals based on their standard phosphate production (Ministry of Agriculture, Nature & Food Quality, 2001). The standard phosphate production of one dairy cow is equivalent to one Phosphate Livestock Unit.

The weighted average of the national FADN sample has been used to ascertain the extent to which the characteristics of dairy farms participating in the derogation monitoring network deviate from those of other dairy farms. The Agricultural Census does not include appropriate data for comparison. The comparison (see Table 2.8) shows that in all regions, the dairy farms participating in the derogation monitoring network have a larger acreage and produce more milk per farm than the weighted national average. A similar comparison has not been performed for the Loess Region due to an insufficient number of FADN-registered farms. The average milk production per hectare and per dairy cow on dairy farms participating in the derogation monitoring network differed little from the national FADN average.

Table 2.8 Average milk production and grazing periods on dairy farms participating in the derogation monitoring network (DMN) in 2012, compared to the weighted average for dairy farms in the national FADN sample

Farm characteristic	*Population*	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Number of farms in DMN	DMN	134	17	60	51	262
FPCM[1] production per farm (kg)	DMN	855,000	706,400	994,300	937,900	893,400
	FADN	729,700		792,100	612,300	718,800
FPCM[1] production per hectare of fodder crop	DMN	16,300	15,800	15,400	14,400	15,700
	FADN	16,000		14,300	13,000	15,000
FPCM[1] production per dairy cow (kg)	DMN	8,620	8,410	8,390	8,220	8,480
	FADN	8,720		8,320	7,980	8,480
Percentage of farms with grazing from May to October	DMN	82	82	68	82	79
	FADN	76		81	89	80
Percentage of farms with grazing from May to June	DMN	79	82	68	82	77
	FADN	74		80	89	79
Percentage of farms with grazing from July to August	DMN	81	82	68	82	79
	FADN	75		81	89	79
Percentage of farms with grazing from September to October	DMN	78	82	63	78	75
	FADN	70		76	86	75

[1] FPCM = Fat and Protein Corrected Milk, a standard used to compare milk with different fat and protein contents (1 kg of FPCM is defined as 1 kg of milk with 4.00 percent fat content and 3.32 percent protein content).

2.8 Characteristics of farms where water quality samples were taken

The sampled farms were distributed across the four soil type regions (see Figure 2.1). The map divides the Sand Region into three sub-regions: North, Central and South. The farm density is higher in the Loess Region. The reason for this is that at least fifteen farms must be sampled in order to draw properly substantiated conclusions (Fraters and Boumans, 2005). The map also makes a distinction between dairy farms and other grassland farms.

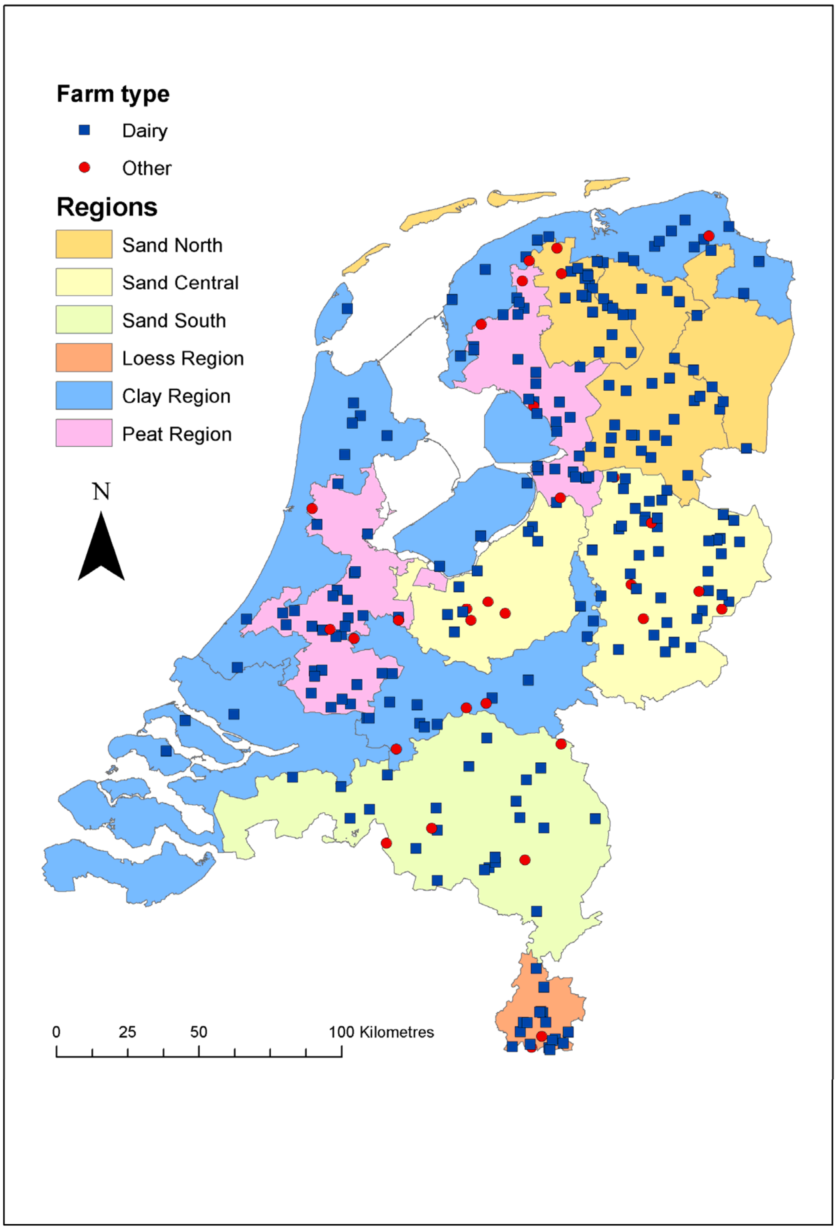

Figure 2.1 Locations of the 283 grassland farms with reported data in 2012 where water samples were taken for derogation monitoring purposes

Within a particular region, other soil types occur in addition to the main soil type for which the region is named (see Table 2.9 and Table 2.10). The Loess Region mainly consists of soils with good drainage, whereas the Peat Region mainly consists of soils with poor drainage. The well-drained soils in the Sand Region are under-represented in the derogation monitoring network. Traditionally, the best soils (with favourable drainage conditions and nutrient status) were used for arable farming, while poorer (i.e. wetter) soils were used for dairy farming. In addition, the driest soils in the Sand Region are often not used for agricultural purposes. Wetter sandy soils are therefore overrepresented in the derogation monitoring network. The differences in soil type and drainage class in the derogation monitoring network between 2012 and 2013 are minimal.

Table 2.9 Relative distribution (in percentages) of soil types and drainage classes in the different regions, for derogation farms where samples were taken in 2012

Region	*Soil type*				*Drainage class*[1]		
	Sand	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	87	0	5	8	40	51	9
Loess	1	80	19	0	1	3	96
Clay	5	0	92	4	45	51	4
Peat	11	0	28	61	95	5	0

[1] The drainage class is linked to the water table class (*Grondwatertrap*, Gt). The 'Poor natural drainage' class comprises water table class Gt I through Gt IV, the 'Moderate drainage' class comprises water table class Gt V, Gt V* and Gt VI, and the 'Good drainage' class comprises water table class Gt VII and Gt VIII.

Table 2.10 Relative distribution (in percentages) of soil types and drainage classes in the different regions, for derogation farms where samples were taken in 2013

Region	*Soil type*				*Drainage class*[1]		
	Sand	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	86	0	6	8	39	50	10
Loess	*	*	*	*	*	*	*
Clay	5	0	92	3	46	49	5
Peat	13	0	27	60	94	5	0

[1] The drainage class is linked to the water table class (*Grondwatertrap*, Gt). The 'Poor natural drainage' class comprises water table class Gt I through Gt IV, the 'Moderate drainage' class comprises water table class Gt V, Gt V* and Gt VI, and the 'Good drainage' class comprises water table class Gt VII and Gt VIII.

* Results from the Loess Region were not yet available when the present report was being prepared.

3 Results

3.1 Agricultural characteristics

3.1.1 Nitrogen use in livestock manure

In 2012, the average use of nitrogen in livestock manure on derogation farms (including manure excreted during grazing) was approx. 11 kg per hectare below the livestock manure application standard of 250 kg per hectare (see Table 3.1). In all regions, less nitrogen in livestock manure was applied on arable land (mainly land used for cultivation of silage maize) than on grassland. The farms in the monitoring network both import and export livestock manure. As the average production exceeded the permitted use, the average manure outputs exceeded the inputs (including stock changes). This applied to all regions (see Table 3.1). On average, the use of livestock manure in 2012 (including rounding-off differences) exceeded the 2011 levels by 7 kg of nitrogen per hectare (see Appendix 4, Table A4.2A).

Table 3.1 Average nitrogen use in livestock manure (in kg of nitrogen per hectare) in 2012 on farms participating in the derogation monitoring network (regional averages)

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Number of farms	144	19	63	55	281
Produced on farm[1]	270	265	253	259	263
+ Inputs	11	9	14	7	11
+ Changes in stocks[2]	-5	-3	-5	-5	-5
- Outputs	37	25	24	23	30
Total	239	246	238	237	239
Use on arable land[3]	178	172	154	193	175
Use on grassland[3]	256	266	251	244	253

[1] Calculated on the basis of standard quantities (N=175), with the exception of dairy farms that indicated they were using the guidance document on farm-specific excretion by dairy cattle (N=106) (see Appendix 2).

[2] A negative change in stocks is a stock increase and corresponds to output.

[3] The average use data and the application standards for grassland and arable land are based on 268 farms and 203 farms, respectively, instead of on 281 farms. This is because on 13 farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit (see Appendix 2, Table A2.1; this can happen if the allocation of fertiliser use to grassland and arable land is not possible), and because 65 farms had no arable land.

Almost 25 percent of all farms in the monitoring network did not import or export livestock manure (see Table 3.2). Nearly 25 percent of all farms only imported livestock manure and did not export it. These farmers were probably of the opinion that importing nutrients in livestock manure offered economic benefits compared to using inorganic fertilisers. This may also apply to the farmers who both imported and exported livestock manure (14 percent).

Table 3.2 Percentage of farms participating in the derogation monitoring network with livestock manure inputs and/or outputs in 2012 (regional averages)

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
No inputs or outputs	17	16	30	29	22
Only outputs	44	47	35	36	41
Only inputs	23	21	21	25	23
Both inputs and outputs	15	16	14	9	14

3.1.2 *Nitrogen and phosphate use compared to nitrogen and phosphate application standards*

In 2012, the calculated total use of plant-available nitrogen at farm level on farms participating in the derogation monitoring network was lower than the nitrogen application standard in all regions except the Loess Region, where the total use was approximately equal to the application standard (see Table 3.3).

Table 3.3 Average use of nitrogen in fertilisers (expressed in kg of plant-available nitrogen per hectare)[1] on farms participating in the derogation monitoring network in 2012 (regional averages)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Number of farms		144	19	63	55	281
Average statutory availability coefficient for livestock manure (%)		49	49	51	48	49
Fertiliser use	Livestock manure	117	120	122	115	118
	Other organic fertilisers	0	0	0	0	0
	Inorganic fertilisers	119	118	146	122	125
	Total average fertiliser use	236	237	268	237	243
	Nitrogen application standard	239	235	295	271	257
Use of plant-available nitrogen on arable land[2]		122	137	125	130	125
Application standard for arable land[2]		141	146	153	152	145
Use of plant-available nitrogen on grassland[2]		270	259	293	250	271
Application standard for grassland[2]		266	264	318	283	281

[1] Calculated on the basis of the applicable statutory availability coefficients (see Appendix 2).
[2] The average use data and the application standards for grassland and arable land are based on 268 farms and 203 farms, respectively, instead of on 281 farms. This is because on 13 farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit (see Appendix 2, Table A2.1; this can happen if the allocation of fertiliser use to grassland and arable land is not possible), and because 65 farms had no arable land.

In 2012, the average total use of phosphate on farms participating in the derogation monitoring network was slightly lower than the average application standard of 89 kg of phosphate per hectare (see Table 3.4). On average nearly 97 percent of phosphate was applied in the form of livestock manure.

Table 3.4 Average use of phosphate in fertilisers (in kg of P_2O_5 per hectare) in 2012 on farms participating in the derogation monitoring network (regional averages)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Number of farms		144	19	63	55	281
Fertiliser use	Livestock manure	83	88	86	82	84
	Other organic fertilisers	0	0	1	0	0
	Inorganic fertilisers	3	6	3	2	3
	Total average fertiliser use	87	94	89	84	87
	Phosphate application standard[4]	87	86	91	91	89
Use of phosphate on arable land[1,2]		75	78	74	82	76
Application standard for arable land[1]		68	66	70	68	68
Use of phosphate on grassland[1,3]		91	99	91	86	90
Application standard for grassland[1]		92	93	94	93	93

[1] The average use data and the application standards for grassland and arable land are based on 268 farms and 203 farms, respectively, instead of on 281 farms. This is because on 13 farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit (see Appendix 2, Table A2.1; this can happen if the allocation of fertiliser use to grassland and arable land is not possible), and because 65 farms had no arable land.
[2] Phosphate use on arable land is reported by the dairy farmer.
[3] Grassland usage levels are calculated by deducting the quantity applied on arable land from the total quantity applied.
[4] The phosphate application standard for a farm depends on the crop (grass or maize) and the fertility of the soil (low-neutral-high).

3.1.3 Crop yields

In 2012, farms participating in the derogation monitoring network had an estimated average dry-matter yield of silage maize of 16,900 kg per hectare, resulting in an estimated average yield of 180 kg of nitrogen and 31 kg of phosphorus (72 kg of P_2O_5). Yields in the Clay Region, Loess Region and Sand Region slightly exceeded the national average, while yields in the Peat Region were below the national average (Table 3.5).
The calculated grassland dry-matter yield amounted to nearly 65 percent of the estimated silage maize yield. However, both the nitrogen and phosphorus yields per hectare were higher due to higher nitrogen and phosphorus contents in grass. The calculated grassland dry-matter yields were highest in the Clay Region.

Table 3.5 Average crop yields (in kg of dry matter, nitrogen, phosphorus and P_2O_5 per hectare) for silage maize (estimated) and grassland (calculated) in 2012, on farms participating in the derogation monitoring network that meet the criteria for application of the calculation method (Aarts et al., 2008) (regional averages)

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Silage maize yields					
Number of farms	103	7	27	23	160
Kilogrammes of dry matter per hectare	17,000	17,100	17,500	15,800	16,900
Kilogrammes of nitrogen per hectare	179	192	191	165	180
Kilogrammes of phosphorus per hectare	31	32	35	29	31
Kilogrammes of P_2O_5 per hectare	71	73	80	67	72
Grassland yields					
Number of farms	118	9	48	43	218
Kilogrammes of dry matter per hectare	10,600	10,800	11,200	10,700	10,800
Kilogrammes of nitrogen per hectare	258	261	262	261	259
Kilogrammes of phosphorus per hectare	39	39	41	38	39
Kilogrammes of P_2O_5 per hectare	90	89	93	87	90

3.1.4 Nutrient surpluses

The average nitrogen surplus on the soil surface balance of farms in the derogation monitoring network amounted to 188 kg per hectare in 2012 (Table 3.6). In 2012, both inputs (nitrogen via feed products and manure) and outputs (nitrogen via animals and manure) were lower than in 2011 (see Table A4.6 in Appendix 4). The variation in nitrogen surpluses on the soil surface balance was considerable. The 25 percent of farms with the lowest surpluses realised a surplus of less than 138 kg of nitrogen per hectare, whereas the surplus exceeded 224 kg of nitrogen per hectare on the 25 percent of farms with the highest surpluses. A possible explanation may be that farmers with a low nitrogen soil surplus are able to effectively integrate environmental aims into their farm management practices (Van den Ham *et al.*, 2010). Farms with a low surplus may also have relatively high crop yields, whereas farms with a high surplus may have soils producing relatively low yields.

Table 3.6 Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms in the derogation monitoring network in 2012 (average values and 25th and 75th percentile values per region)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Number of farms		144	19	63	55	281
Farm inputs	Inorganic fertilisers	119	118	146	122	125
	Livestock manure and other organic fertilisers	11	6	15	6	10
	Feedstuffs	217	176	158	172	192
	Animals	2	1	2	2	2
	Other	2	2	2	1	2
	Total	350	303	323	303	332
Farm outputs	Milk and other animal products	83	71	74	78	79
	Animals	25	12	11	14	19
	Livestock manure	41	26	29	27	34
	Other	21	29	21	14	20
	Total	170	138	135	132	153
Average nitrogen surplus per farm		180	166	187	171	179
+ Deposition, mineralisation and organic nitrogen fixation		43	41	42	124[1]	58
- Gaseous emissions[2]		48	48	51	52	50
Average nitrogen surplus on soil surface balance[3]		174	159	179	242	188
Nitrogen surplus on soil surface balance, 25th percentile		125	150	152	145	138
Nitrogen surplus on soil surface balance, 75th percentile		218	220	243	272	224

[1] Based on the assumption that an additional 160 kg of nitrogen mineralises from organic matter on peat soil
[2] Gaseous emissions resulting from stabling, storage, application and grazing
[3] Calculated in accordance with method described in Appendix 2

The average phosphate surplus on the soil surface balance was 9 kg per hectare (see Table 3.7). In 2012, both inputs (phosphate via feed products and manure) and outputs (phosphate via animals and manure) were lower than in 2011 (see Table A4.8 in Appendix 4). The 25 percent of farms with the lowest phosphate surpluses realised a surplus of less than -1 kg per hectare (0 kg/ha = balance), whereas the surplus exceeded 20 kg per hectare on the 25 percent of farms with the highest surpluses. As in the case of nitrogen soil surpluses, these differences could be explained by the assumption that farmers with a low phosphate soil surplus are able to effectively integrate environmental aims into their farm management practices (Van den Ham *et al.*, 2010). Additionally, some of these farms may have relatively high crop yields, while farms with a high surplus may have soils producing relatively low yields.

Table 3.7 Phosphate surpluses on the soil surface balance (in kg of P_2O_5 per hectare) on farms in the derogation monitoring network in 2012 (average values and 25th and 75th percentile values per region)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*All types*
Number of farms		144	19	63	55	281
Farm inputs	Inorganic fertilisers	3	6	3	2	3
	Livestock manure and other organic fertilisers	5	3	7	3	5
	Feedstuffs	75	59	52	60	66
	Animals	1	1	1	1	1
	Other	0	1	0	0	0
	Total	85	69	64	66	75
Farm outputs	Milk and other animal products	33	29	30	30	31
	Animals	13	8	8	9	11
	Organic fertilisers	18	10	12	14	15
	Other	9	11	9	7	9
	Total	73	58	58	60	66
Average phosphate surplus on soil surface balance[1]		12	11	5	6	9
Phosphate surplus on soil surface balance, 25th percentile		-2	-6	1	0	-1
Phosphate surplus on soil surface balance, 75th percentile		19	14	23	19	20

[1] Calculated in accordance with method described in Appendix 2

3.2 Water quality

3.2.1 Water leaching from the root zone, measured in 2012 (NO_3, N and P)

In 2012, the average nitrate concentrations in the Sand Region, Clay Region and Peat Region were below the nitrate standard of 50 mg/l (see Table 3.8). The average nitrate concentration in the Loess Region was 55 mg/l. Although nitrate concentrations in the Peat Region were lower than in the Clay Region, the total nitrogen concentration was higher. This is caused by higher ammonium concentrations in groundwater in the Peat Region. The higher ammonium concentrations are probably due to nutrient-rich peat layers (Van Beek *et al.*, 2004) in which nitrogen is released in the form of ammonium due to the decomposition of organic matter (Butterbach-Bahl and Gundersen, 2011).

Groundwater that is or has been in contact with nutrient-rich peat layers often has high phosphorus concentrations (Van Beek *et al.*, 2004). These nutrient-rich peat layers may also partly cause the higher average phosphorus concentrations measured in the Peat and Clay Regions compared to the concentrations measured in the Sand Region. In addition, phosphate ions are easily adsorbed by iron and aluminium (hydr)oxides and clay minerals, particularly under acidic circumstances such as those occurring in the Sand Region. Phosphate also readily precipitates in the form of poorly soluble aluminium, iron and calcium phosphates.

Table 3.8 Nutrient concentrations (in mg/l) in water leaching from the root zone in 2012 on farms in the derogation monitoring network (average concentrations per region and percentage of observations below the phosphorus detection threshold)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	138	19	58	51
Nitrate (NO_3)	36	55	10	4
Nitrogen	11.5	14.2	4.7	8.0
Phosphorus[1] (P)	0.09 (62)	<DT (89)	0.34 (19)	0.42 (10)

[1] The percentage of farms with average concentrations below the Detection Threshold (DT) is stated in parentheses.

In 2012, 74 percent of farms in the Sand Region had nitrate concentrations below the nitrate application standard of 50 mg/l. In the Loess Region, 47 percent of farms had below-standard nitrate concentrations (see Table 3.9). In the Clay and Peat Regions, all farms had below-standard nitrate concentrations. The higher percentage of farms in the Sand and Loess Regions with nitrate concentrations above the nitrate standard is due to a higher percentage of soils prone to leaching in these regions. These are soils where less denitrification occurs, partly due to lower groundwater levels and/or limited availability of organic material and pyrite (Biesheuvel, 2002; Fraters *et al.*, 2007a; Boumans and Fraters, 2011).

Table 3.9 Frequency distribution in 2012 of farm-specific average nitrate concentrations (in mg of NO_3/l) in water leaching from the root zone on farms in the derogation monitoring network per region, expressed as percentages per class

Concentration class (mg NO_3/l)	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	138	19	58	51
<15	30	0	74	88
15-25	14	11	12	10
25-40	15	21	9	2
40-50	15	16	5	0
>50	26	53	0	0

In 2012, 50 percent of all farms in the Sand Region had a nitrogen concentration of 10.4 mg N/l or lower (see Table 3.10). The median value for the Loess Region was 13.9 mg N/l. Fifty percent of all farms in the Peat Region had a nitrogen concentration of 7.0 mg N/l or lower. The median value for the Clay Region was 3.6 mg N/l.

Table 3.10 Nitrogen concentrations in 2012 (in mg N/l) in water leaching from the root zone on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	138	19	58	51
First quartile (25th percentile)	7.0	9.2	2.5	5.7
Median (50th percentile)	10.4	13.9	3.6	7.0
Third quartile (75th percentile)	14.6	17.2	6.0	10.8

Phosphorus concentrations on 75 percent of farms in the Sand Region were equal to or less than 0.08 mg P/l (see Table 3.11). Phosphorus concentrations on 50 percent of farms in the Clay Region were equal to or less than 0.24 mg P/l. The median value for farms in the Peat Region was 0.26 mg P/l. In the Loess Region, over 75 percent of farms had a phosphorus concentration below the detection threshold.

Table 3.11 Phosphorus concentrations[1] in 2012 (in mg P/l) in water leaching from the root zone on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	138	19	58	51
First quartile (25th percentile)	<DT	<DT	0.1	0.12
Median (50th percentile)	<DT	<DT	0.24	0.26
Third quartile (75th percentile)	0.08	<DT	0.40	0.43

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT

3.2.2 *Ditch water quality measurements in 2011-2012 (nitrogen and phosphorus)*

Average nitrate concentrations were highest in the Sand Region at 20 mg/l, and lowest in the Peat Region at 3 mg/l (see Table 3.12). Nitrogen concentrations, too, were highest in the Sand Region (6.8 mg N/l). Similar to the results for water leaching from the root zone, the average nitrogen concentration in the Peat Region (4.0 mg N/l) was higher than in the Clay Region (3.1 mg N/l). Phosphorus concentrations in ditch water were highest in the Clay Region, and lowest in the Sand Region.

Table 3.12 Average ditch water nutrient concentrations (in mg/l) per region in the winter of 2011-2012 on farms in the derogation monitoring network

Characteristic	*Region*			
	Sand	*Loess**	*Clay*	*Peat*
Number of farms[1]	34	*	57	50
Nitrate (NO_3)	20	*	5	3
Nitrogen (N)	6.8	*	3.1	4.0
Phosphorus (P)	0.11	*	0.26	0.16

* There are no farms with ditches in the Loess Region.

[1] There is one farm without ditches in both the Clay Region and the Peat Region.

Of the 34 farms in the Sand Region, 31 farms (91 percent) had ditch water nitrate concentrations equal to or less than 50 mg/l (see able 3.13). All farms in the Clay and Peat Regions had ditch water nitrate concentrations below 50 mg/l. Fifty percent of the farms in the Sand Region had ditch water nitrogen concentrations equal to or less than 5.6 mg N/l (see Table 3.14). Fifty percent of all farms in the Clay and Peat Regions had ditch water nitrogen concentrations equal to or less than 2.5 mg N/l and 3.7 mg N/l, respectively.

able 3.13 Frequency distribution of average ditch water nitrate concentrations (in mg NO_3/l) per farm, on farms in the derogation monitoring network in the winter of 2011-2012, expressed as percentages per class per region

Concentration class (mg NO_3/l)	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms[1]	34	*	57	50
<15	56	*	91	98
15-25	9	*	9	0
25-40	24	*	0	2
40-50	3	*	0	0
>50	9	*	0	0

* There are no farms with ditches in the Loess Region.

[1] There is one farm without ditches in both the Clay Region and the Peat Region.

Table 3.14 Ditch water nitrogen concentrations (in mg N/l) on farms in the derogation monitoring network in the winter of 2011-2012 (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess**	*Clay*	*Peat*
Number of farms	34	0	57	50
First quartile (25th percentile)	3.7	-	1.9	3.0
Median (50th percentile)	5.6	-	2.5	3.7
Third quartile (75th percentile)	9.1	-	3.8	5.0

* There are no farms with ditches in the Loess Region.

Fifty percent of farms in the Sand Region had ditch water phosphorus concentrations below the detection threshold of 0.062 mg P/l (see Table 3.15). Fifty percent of farms in the Peat Region had phosphorus concentrations equal to or less than 0.11 mg P/l. The highest concentrations were found in the Clay Region, where 50 percent of farms had a phosphorus concentration equal to or less than 0.14 mg P/l.

Table 3.15 Ditch water phosphorus concentrations[1] (in mg P/l) in the winter of 2011-2012 on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess**	*Clay*	*Peat*
Number of farms	34	0	57	50
First quartile (25th percentile)	<DT	-	<DT	<DT
Median (50th percentile)	<DT	-	0.14	0.11
Third quartile (75th percentile)	0.19	-	0.49	0.18

* There are no farms with ditches in the Loess Region.

[1] Average values below the detection threshold of 0.062 mg P/l are indicated by the abbreviation <DT.

3.2.3 *Comparison with provisional figures for 2012 as reported*

The figures presented in this section hardly deviate from the provisional figures reported in Hooijboer *et al.* (2013). These minor differences are mainly caused by a number of farms having 'dropped out' because these farms did not qualify for participation or did not actually participate in the derogation scheme, or because farms were replaced in the derogation monitoring network.

3.2.4 *Provisional figures for measurement year 2013 (nitrogen and phosphorus)*

Only provisional results are available for 2013. No results for the Loess Region were available when this report was being prepared. 'Provisional' means that the results are reasonably certain, although various cross-checks have not yet been performed. This could mean that some concentration data might be changed in the final report for 2013, which will be published in 2015. In addition, it is currently unknown if the sampled farms actually participated in the derogation scheme in 2013.

In the Sand Region, the average nitrate concentration in water leaching from the root zone was 38 mg/l (Table 3.16). Nitrate concentrations at 68 percent of farms were below 50 mg/l. This is a lower percentage than in 2012 (see Table 3.9). In 2013, the average nitrate concentration in water leaching from the root zone in the Clay Region was 11 mg/l. Ninety-seven percent of the participating farms in the Clay Region had nitrate concentrations below 50 mg/l (see Table 3.16). The average nitrate concentration on farms in the Peat Region was 6 mg/l. In this region, all farms had nitrate concentrations below 50 mg/l.

In 2013, the average ditch water nitrate concentration in the Clay and Peat Regions amounted to 5 mg/l and 2 mg/l, respectively. These levels are well below the nitrate standard of 50 mg/l (see Table 3.16). At 20 mg/l, the average ditch water nitrate concentration in the Sand Region exceeded the average concentration in the Clay and Peat Regions and remained stable compared to 2012.

Table 3.16 Frequency distribution of average nitrate concentrations (in mg NO_3/l) in water leaching from the root zone (left section of table) and in ditch water (right section) per region in 2013, expressed in percentages per concentration class and average nitrate concentrations for all farms

Concentration class (mg NO_3/l)	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess**	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	154	*	68	57	35	67	56
Average concentration for all farms	38	*	11	6	20	5	2
<15	27	*	78	86	57	93	98
15-25	15	*	10	5	11	6	2
25-40	18	*	6	5	11	1	0
40-50	8	*	3	4	11	0	0
>50	32	*	3	0	9	0	0

* Results from the Loess Region were not yet available at the time of preparation of the present report.

Nitrogen concentrations in water leaching from the root zone were higher in the Sand Region than in the Clay and Peat Regions (see Table 3.17). It is also noteworthy that nitrogen concentrations in the Peat Region were higher than in the Clay Region, due to higher ammonium concentrations in the Peat Region. The ditch water nitrogen concentrations presented a similar picture to concentrations in water leaching from the root zone, but with lower concentration levels.

Table 3.17 Nitrogen concentrations (in mg N/l) in water leaching from the root zone (left section of table) and in ditch water (right section) in 2013 on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess**	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	154	*	68	57	35	67	56
Average	11.4	*	4.6	8.3	6.9	3.4	4.1
First quartile (25th percentile)	6.7	*	2.3	5.8	3.7	1.7	2.9
Median (50th percentile)	9.6	*	3.4	7.2	5.2	2.5	3.9
Third quartile (75th percentile)	14.7	*	5.3	9.3	10.0	3.6	5.1

* Results from the Loess Region were not yet available at the time of preparation of the present report.

Unlike the nitrogen concentrations, the phosphorus concentrations in water leaching from the root zone were higher in the Peat Region than in the Clay and Sand Regions (see Table 3.18). In 2013, the ditch water phosphorus concentrations were highest in the Clay Region.

Table 3.18 Phosphorus concentrations[1] (in mg P/l) in water leaching from the root zone (left section of table) and in ditch water (right section) in 2013 on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess**	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	154	*	68	57	35	67	56
Average	0.10	*	0.25	0.43	0.13	0.26	0.20
First quartile (25th percentile)	<DT	*	0.07	0.14	<DT	<DT	<DT
Median (50th percentile)	<DT	*	0.22	0.31	<DT	0.15	0.14
Third quartile (75th percentile)	0.10	*	0.34	0.47	0.14	0.44	0.28

* There are no farms with ditches in the Loess Region.

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT

4 Developments in monitoring results

4.1 Developments in agricultural practices

4.1.1 Developments in farm characteristics

FPCM production per farm, per hectare and per cow all increased during the 2006-2012 period (see Figure 4.1). This also applied to the area of cultivated land per farm. The proportion of farms with intensive livestock and the average livestock density expressed in Phosphate Livestock Units per hectare have decreased (see Figure 4.2). This trend points to a slow, gradual increase in scale and intensification in the dairy farming sector, resulting in higher milk production per hectare of fodder crop (see also Appendix 4, Tables A4.1A and A4.1B). Despite the increase in milk production per hectare of fodder crop, nitrogen production in livestock manure per hectare decreased, particularly after 2010 (see Appendix 4, Table A4.2A).

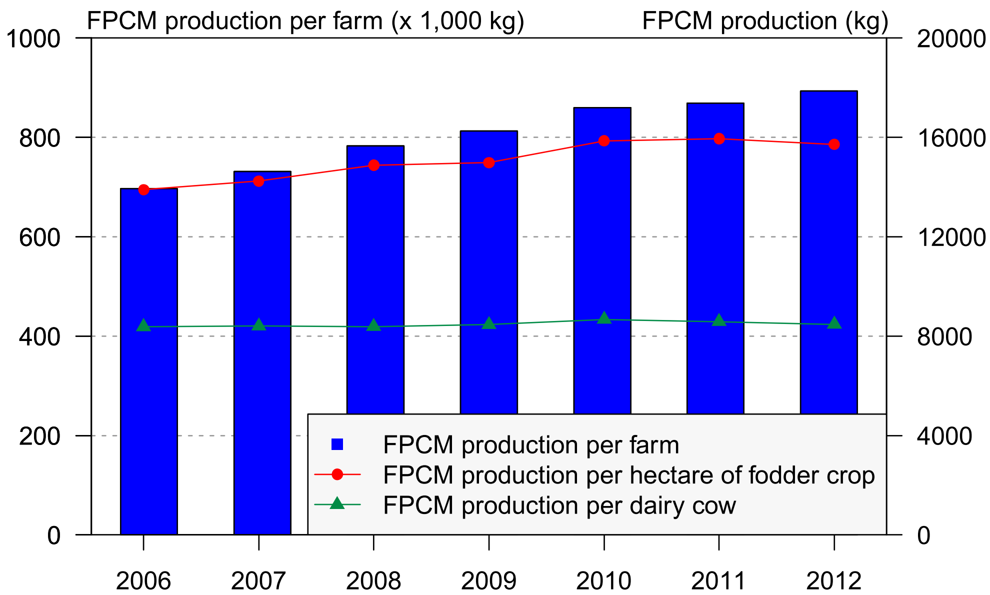

Figure 4.1 Average production of Fat and Protein Corrected Milk (FPCM) per farm, per hectare and per cow in the 2006-2012 period

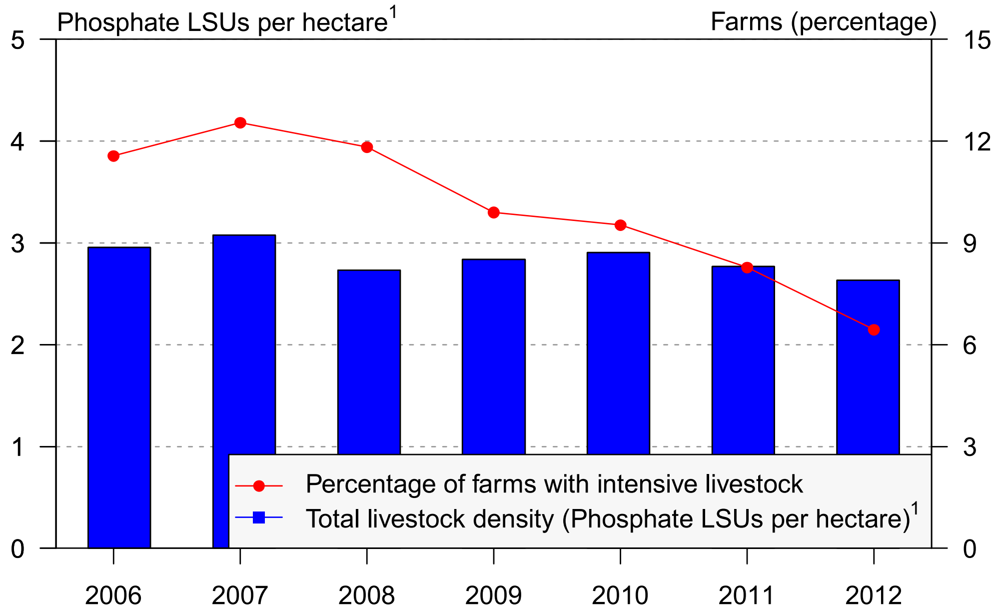

Figure 4.2 Average livestock density expressed in Phosphate Livestock Units per hectare, and percentage of dairy farms with intensive livestock (e.g. pigs, chickens, sheep) in the 2006-2012 period

[1] Phosphate Livestock Unit (LSU) is a standard used to compare numbers of animals based on their standard phosphate production (Ministry of Agriculture, Nature & Food Quality, 2001). The standard phosphate production of one dairy cow is equivalent to one Phosphate Livestock Unit. The use of LSUs enables the aggregation of all animals presenintensive livestockt on a farm (dairy cows, young livestock, pigs, chickens, sheep, etc.).

The percentage of farms with grazing decreased until 2011 and increased in 2012 compared to 2011 (Figure 4.3; see also Appendix 4, Tables A4.1A and A4.1B).

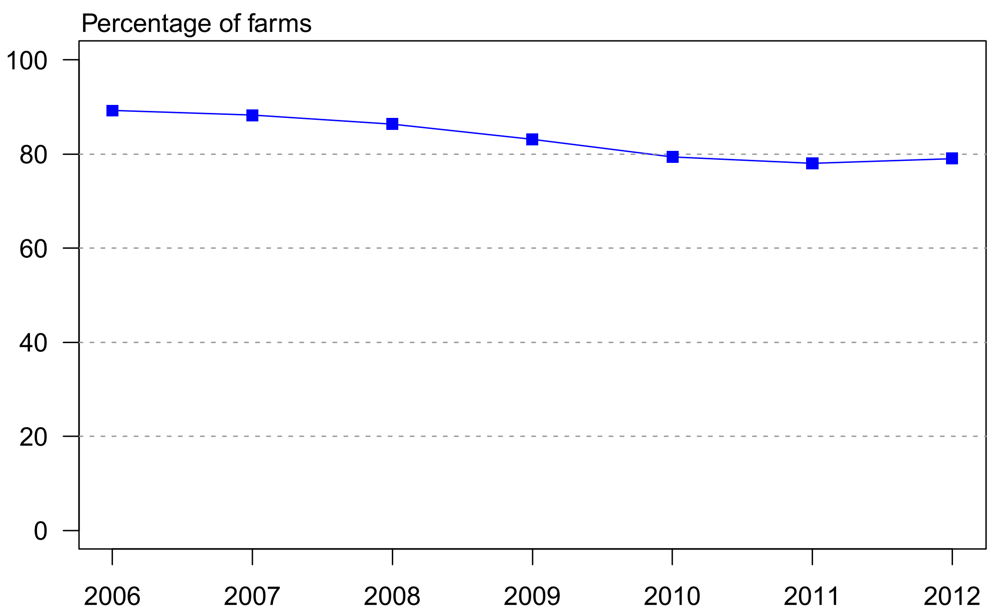

Figure 4.3 Percentage of dairy farms where cows graze in summer in the 2006-2012 period

4.1.2 *Use of livestock manure*

In 2012, the use of nitrogen in livestock manure was comparable to the average for the 2006-2011 period (Figure 4.4; see also Appendix 4, Tables A4.2A and A4.2B).

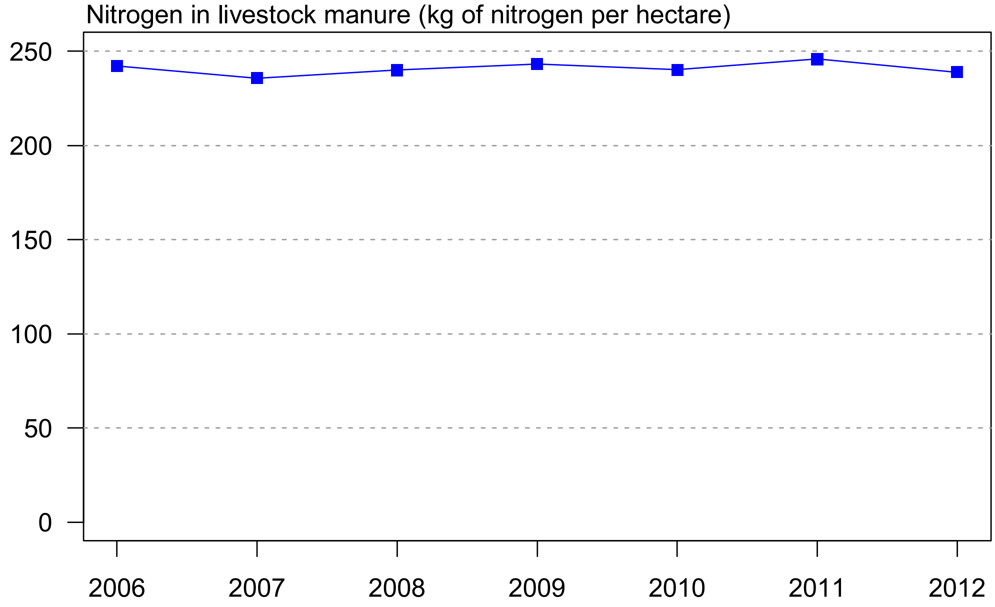

Figure 4.4 Application of nitrogen in livestock manure (in kg of nitrogen per hectare) in the 2006-2012 period

4.1.3 *Use of fertilisers compared to application standards*

In 2012, the total use of plant-available nitrogen still remained below the total application standard, but the difference is decreasing (see Appendix 4, Table A4.3B). Whereas the difference between actual usage and the total application standard for plant-available nitrogen amounted to almost 70 kg per hectare in 2006, this difference had decreased to 14 kg per hectare in 2012. This is partly due to higher statutory availability coefficients for manure on dairy farms with grazing, and partly due to more stringent nitrogen application standards (Figure 4.5; see also Appendix 4, Tables A4.3A and A4.3B).

The use of inorganic nitrogen-containing fertilisers was fairly stable during the 2006-2012 period (see Appendix 4, Table A4.3A). The total applied quantity of plant-available nitrogen in 2012 was slightly higher than the average for the six preceding years. The total use of nitrogen increased. Part of this increase is artificial, as the statutory availability coefficient for livestock manure was increased during this period (see Appendix 4, Tables A4.3A and A4.3B).

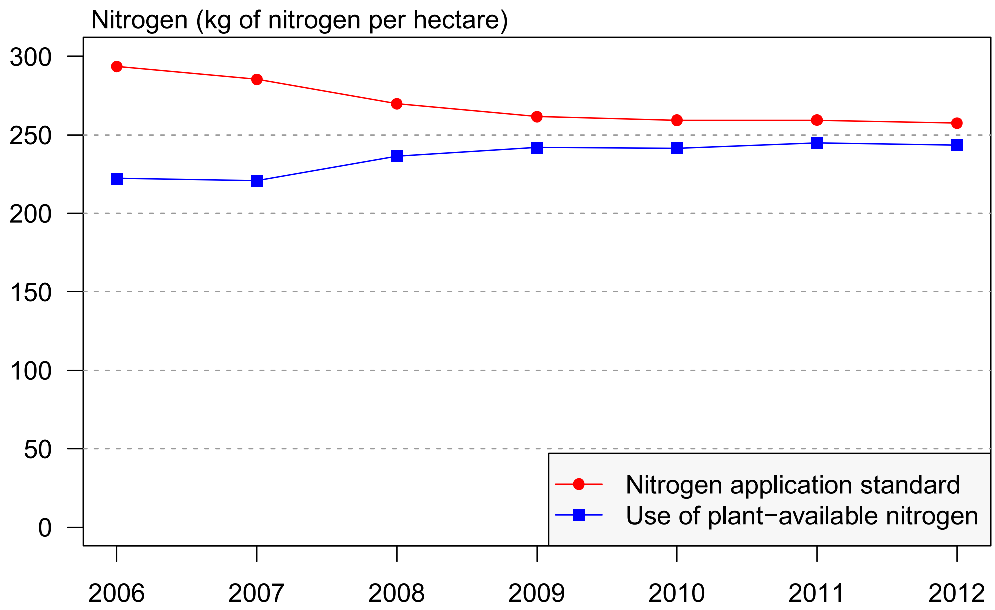

Figure 4.5 Total nitrogen application standard (in kg of nitrogen per hectare) and use of plant-available nitrogen in livestock manure and inorganic fertilisers (in kg of nitrogen per hectare) during the 2006-2012 period

During the 2006-2012 period, the use of phosphate-containing fertilisers on farms participating in the derogation monitoring network decreased by approx. 12 percent, while the phosphate application standard decreased by approx. 18 percent (see Figure 4.5). As a result, the difference between actual phosphate use and the phosphate application standard decreased from approx. 10 kg per hectare in 2006/2007 to 2 kg per hectare in 2012. Between 2006 and 2012, the phosphate application standards were reduced from an average of 108 kg per hectare to an average of 89 kg per hectare. As a result, the initial difference between actual usage and the level prescribed by the standard was eliminated. The decrease of the application standards also resulted in a reduction in use of inorganic phosphate-containing fertilisers (see Appendix 4, Tables A4.4A and A4.4B).

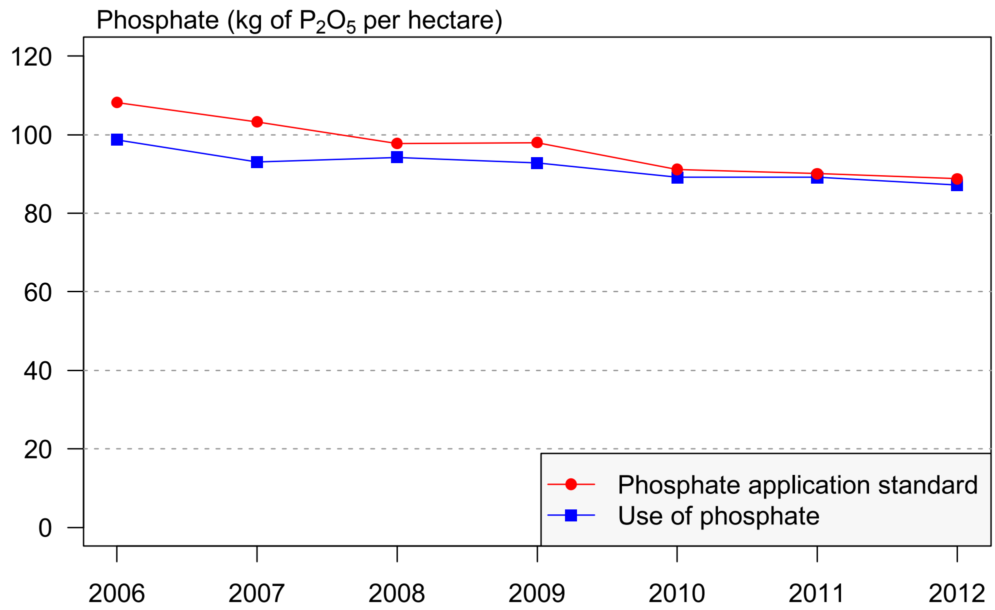

Figure 4.6 Total phosphate application standard (in kg of P_2O_5 per hectare) and use of phosphate in livestock manure (in kg of P_2O_5 per hectare) during the 2006-2012 period

4.1.4 Crop yields

The average dry-matter yields for grass and silage maize increased in the 2006-2012 period (see Figure 4.7; Appendix 4, Tables A4.5A and A4.5B). Yields measured in kilogrammes of nitrogen do not show a clear trend for silage maize, nor for grassland up to and including 2011 (see Figure 4.8; Appendix 4, Tables A4.5A and A4.5B). However, nitrogen yields in 2012 were lower than in previous years. This was caused by lower nitrogen contents in grass in 2012. In 2013, the yields appeared to return to the normal level (Netherlands Laboratory for Soil and Crop Research, 2014). Yields measured in kilogrammes of phosphate increased for silage maize as well as grassland (Figure 4.9; Appendix 4, Tables A4.5A and A4.5B).

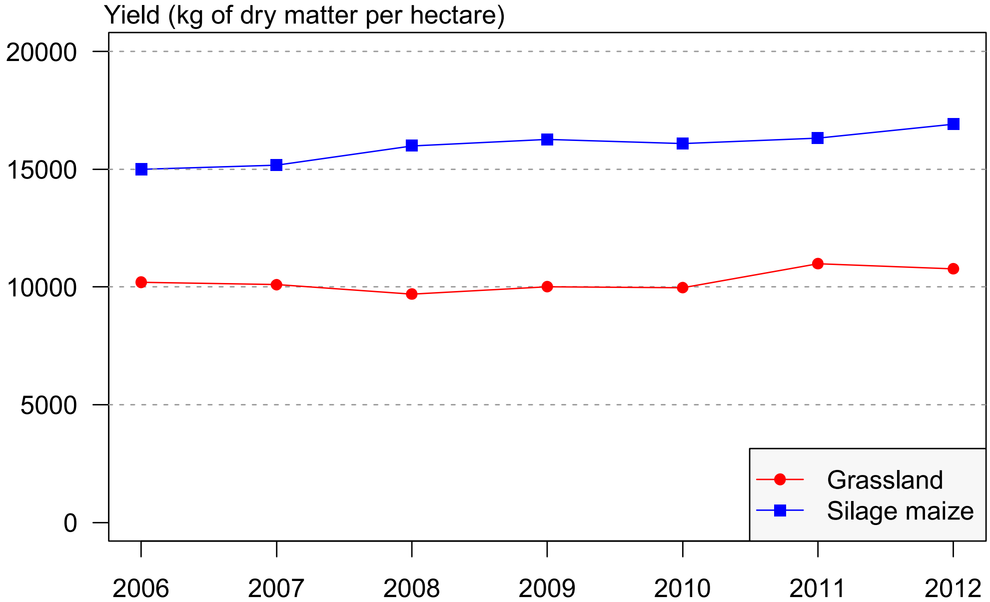

Figure 4.7 Average dry-matter yields for grassland and silage maize on derogation farms in the 2006-2012 period

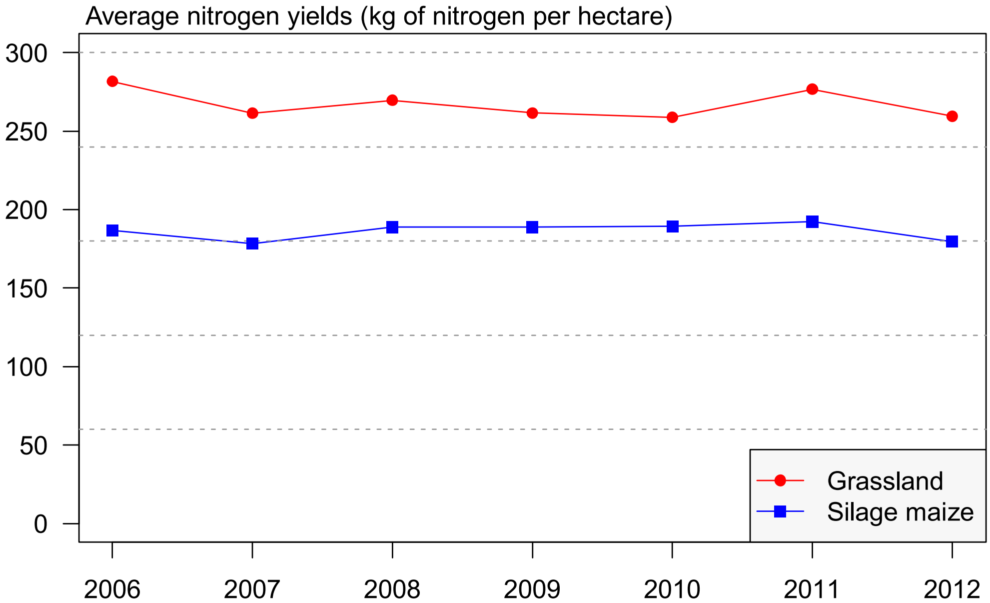

Figure 4.8 Average nitrogen yields (in kg of nitrogen per hectare) for grassland and silage maize on derogation farms in the 2006-2012 period

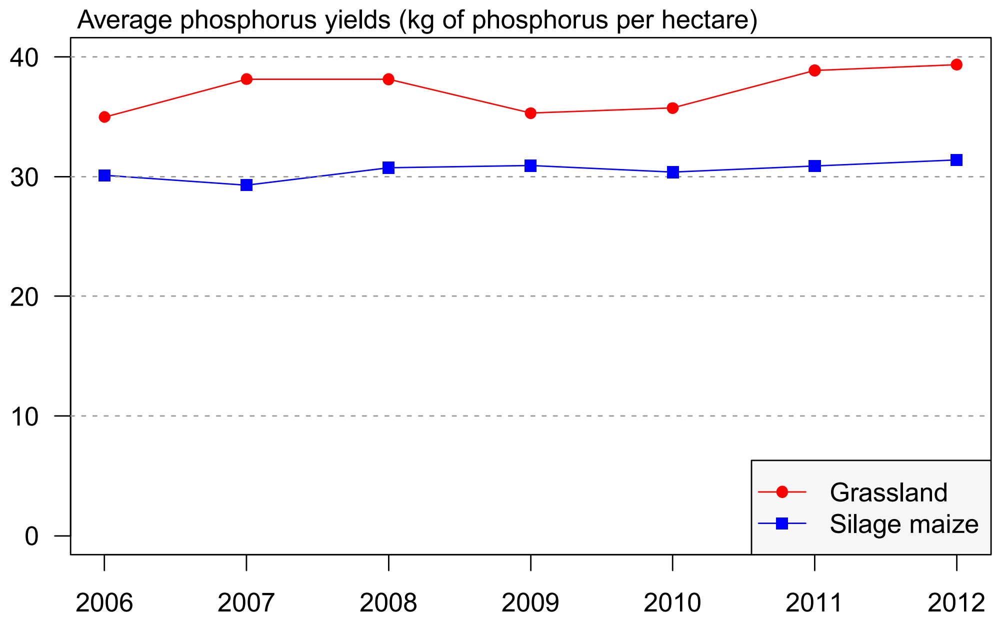

Figure 4.9 Average phosphorus yields (in kg of phosphorus per hectare; 1 kg of phosphorus = 2.29 kg of P_2O_5) for grassland and silage maize on derogation farms in the 2006-2012 period

4.1.5 *Nutrient surpluses on the soil surface balance*

The average nitrogen surplus on the soil surface balance in 2012 did not deviate from the average for the 2006-2011 period. No trend change could be observed in the average nitrogen soil surplus during the 2006-2012 period (see Figure 4.10; Appendix 4, Tables A4.6A and A4.6B). Furthermore, no clear differences or trends were apparent with respect to the different soil type regions (see Figure 4.11; Appendix 4, Tables A4.7A and A4.7B).

The nitrogen soil surplus data presented here differ from the figures for measurement year 2011 (Hooijboer *et al.*, 2013). It turned out that the present report required a correction of the nitrogen content in the roughage stocks on clay soils in 2007. As a result, the nitrogen soil surpluses in 2007 and 2008 were recalculated. These surpluses therefore deviate from the surpluses presented in the 2013 report for both years.

Other differences in nitrogen soil surpluses arose as a result of minor adjustments at farm level or because some farms dropped out. As a result, differences in nitrogen soil surpluses of more than 10 kg of nitrogen per hectare per year may arise for small groups of farms like those in the Peat and Loess Regions.

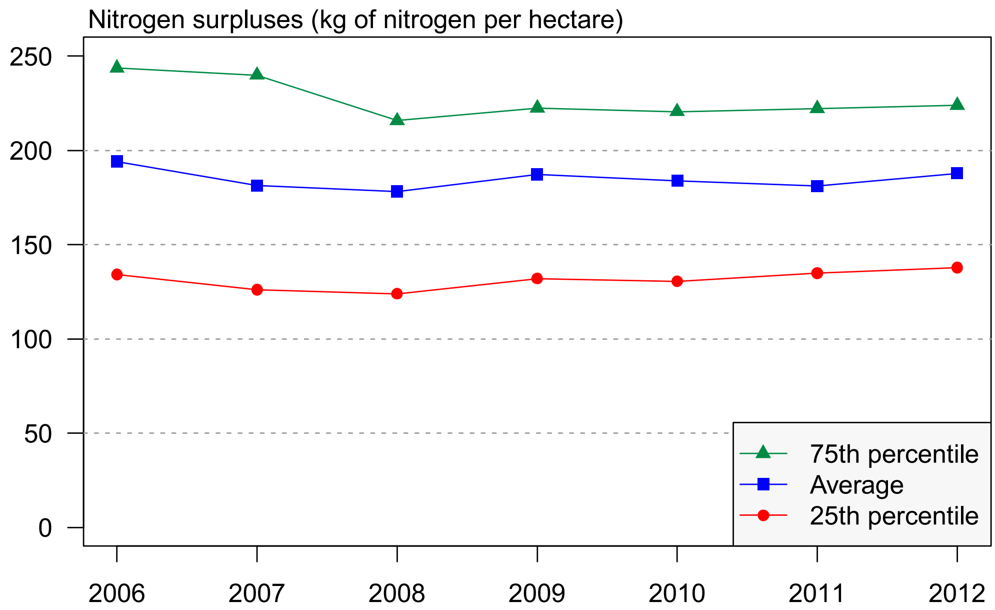

Figure 4.10 Average nitrogen surpluses, nitrogen surpluses on the 25 percent of derogation farms with the lowest surpluses (first quartile or 25th percentile), and nitrogen surpluses on the 25 percent of derogation farms with the highest surpluses (third quartile or 75th percentile) in the 2006-2012 period (expressed in kg of nitrogen per hectare)

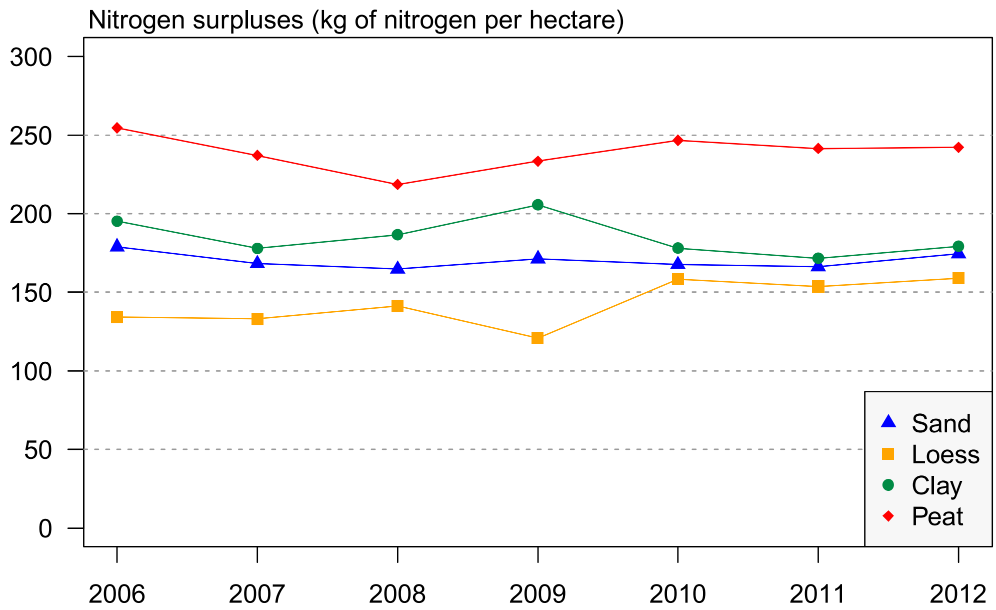

Figure 4.11 Average nitrogen surpluses per region (in kg of nitrogen per hectare) on derogation farms in the 2006-2012 period

In 2012, the phosphate surplus on the soil surface balance was lower than the average for the 2006-2011 period (Figure 4.12; see also Appendix 4, Tables A4.8A and A4.8B). This was caused by lower inputs of phosphate via inorganic fertilisers and feed products (see Appendix 4, Tables A4.4A, A4.4B, A4.8A and A4.8B).

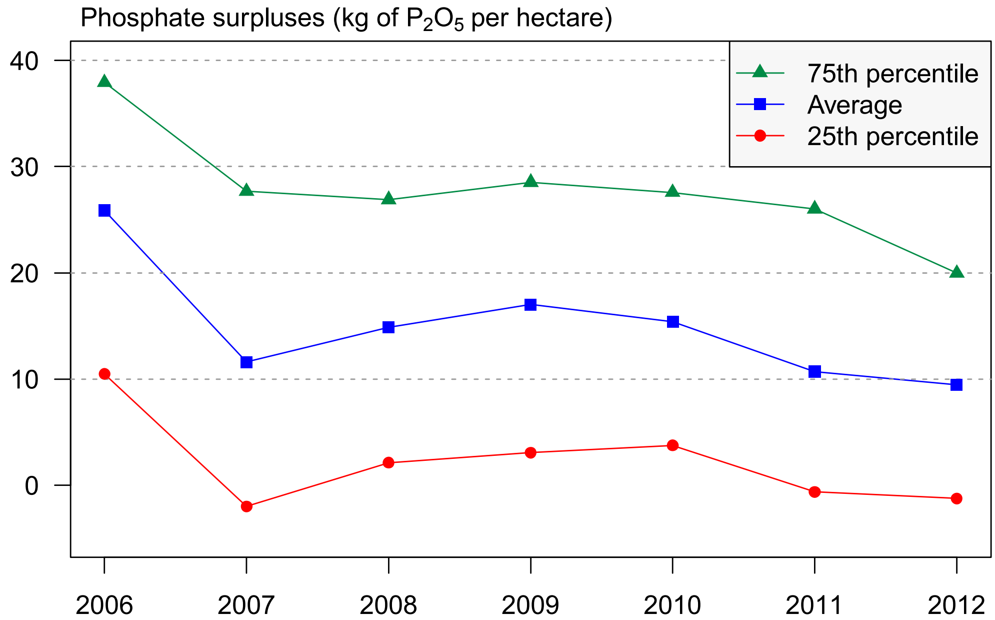

Figure 4.12 Average phosphate surpluses, phosphate surpluses on the 25 percent of derogation farms with the lowest surpluses (first quartile or 25th percentile), and phosphate surpluses on the 25 percent of derogation farms with the highest surpluses (third quartile or 75th percentile) in the 2006-2012 period (expressed in kg of P_2O_5 per hectare)

4.2 Development of water quality

4.2.1 Development of average concentrations during 2007-2013 period

The average nitrate concentrations in ditch water and water leaching from the root zone decreased in all regions (see Figure 4.13; Appendix 4, Tables A4.9A and A4.9B). In addition, nitrate concentrations in the most recent measurement year were lower than the average for the preceding years, except in the Loess Region and in water leaching from the root zone in the Peat Region.

The phosphorus concentrations did not deviate from the average for the preceding years, and displayed no clear trends except an upward trend for ditch water in the Sand Region and a downward trend for ditch water in the Clay Region (see Appendix 4, Table A4.9). Although ditch water phosphorus concentrations in the Sand Region have increased, they remain very low and just above the detection threshold.

Average nitrogen concentrations decreased everywhere, except in ditch water in the Peat Region and in water leaching from the root zone in the Loess Region (see Appendix 4, Table A4.9). In the Loess and Peat Regions, the concentrations in the most recent measurement year did not differ significantly from the average for the preceding years. Average ditch water concentrations in the Clay Region did not differ from previous years. However, concentrations in water leaching from the root zone in the Clay Region and in both types of water in the Sand Region were lower in the most recent measurement year than the average for the preceding years.

The effect of previous years with below-average precipitation was apparent in the 2010 results for the top metre of groundwater. These results revealed higher nitrate concentrations in the Sand, Clay and Peat Regions than in previous and subsequent years.

The average nitrate concentrations were highest in the Loess Region and decreased in the following order: Loess > Sand > Clay > Peat. In the Clay and Peat Regions, the average concentrations amounted to less than 50 mg of nitrate per litre in all years (see Figure 4.13). In the Sand Region, this has been the case since 2008. The average nitrate concentration in the Loess Region only reached the 50 mg/l standard in 2009 and 2010.

The higher nitrate concentrations in the Loess and Sand Regions are caused mainly by a higher percentage of soils prone to leaching. These are soils where less denitrification occurs, partly due to lower groundwater levels (Fraters *et al.*, 2007, Boumans and Fraters, 2011).

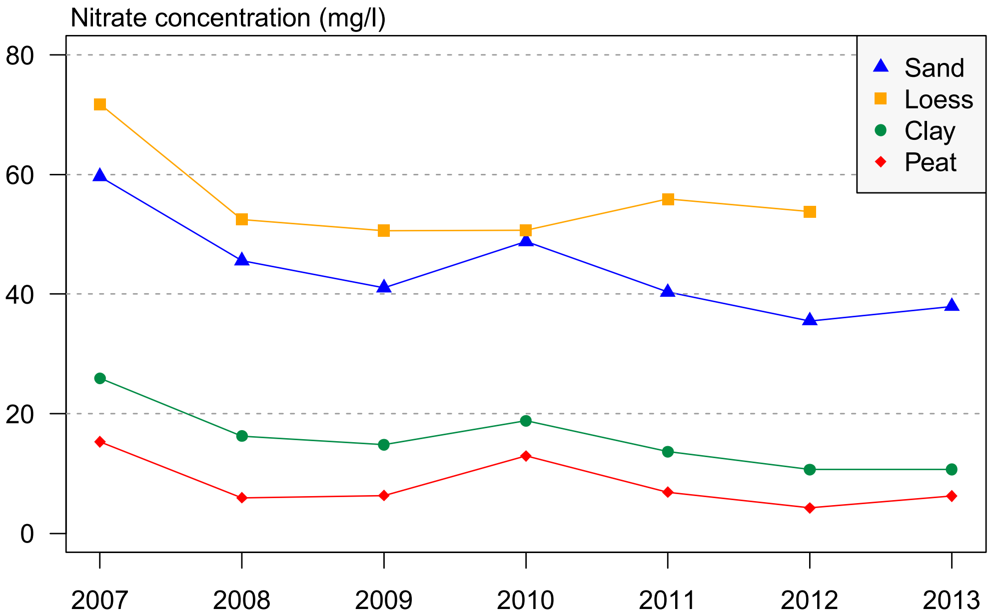

Figure 4.13 Average nitrate concentration in water leaching from the root zone on derogation farms in four regions during the 2007-2013 period

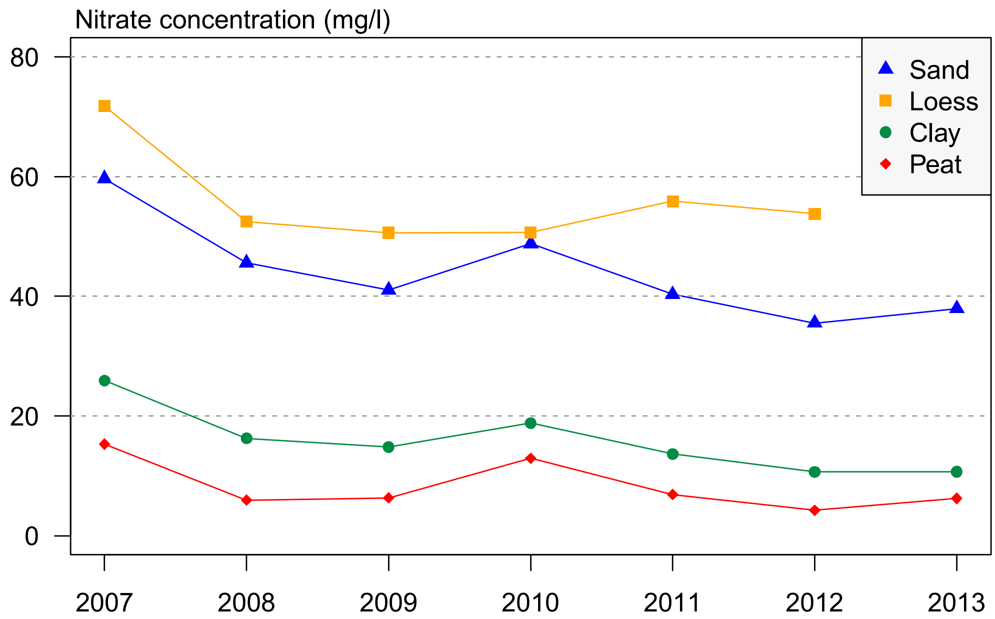

Figure 4.14 Average ditch water nitrate concentration on derogation farms in three regions during the 2007-2013 period

4.2.2 Effects of environmental factors and sample composition on nitrate concentrations

Nitrate concentrations in water leaching from the root zone are not only affected by agricultural practices, but also by environmental factors. Particularly precipitation and temperature have an effect on crop yields, and consequently also on nitrogen output, soil surpluses and nitrogen leaching. Even if a long-term balance is achieved between the annual supply and decomposition of organic matter, mineralisation and immobilisation will not be perfectly balanced in each year. For instance, nitrate leaching may be significantly affected by the ploughing up of grassland and grass-maize rotation (Velthof and Hummelink, 2012). As a result, there will be variations in soil surpluses and nitrogen leaching. The final nitrogen concentration is also affected by the precipitation surplus and by changes in groundwater levels (Boumans *et al.*, 2005; Fraters *et al.*, 2005; Zwart *et al.*, 2009, 2010, 2011). Changes in the composition of the farm sample can also have an effect, since soil types and groundwater levels vary between farms (Boumans *et al.*, 1989).

A statistical method has been developed for the Sand Region in order to correct the measured nitrate concentrations for the effects of weather conditions, groundwater levels and changes in the composition of the sample (Boumans and Fraters, 2011). This method uses relative evaporation as a measure for the impact of annual fluctuations in the precipitation surplus (see Table 4.10). Nitrate concentrations will rise as evaporation increases and groundwater levels decrease, provided other factors do not change. Refer to Hooijboer *et al.* (2013, Appendix 6) for a further explanation of the statistical method used. This method does not take all processes into consideration and is based only on correlations.

If the method is applied, we find that the average corrected nitrate concentrations in the Sand Region dropped significantly from approx. 58 mg/l in

2007 to approx. 41 mg/l in 2013, a reduction of 17 mg/l (see Table 4.1 and Figure 4.15). In recent years, both the measured and the corrected nitrate concentrations have been below the 50 mg/l standard and have displayed a significant downward trend. This downward trend is mainly attributable to the 2007-2009 period.

The nitrate concentrations corrected for weather conditions and sample composition decreased during the 2007-2013 period and have fluctuated around 40 mg/l in the past few years.

Table 4.1 Average nitrate concentrations (in mg/l) in water leaching from the root zone in the Sand Region, measured and corrected for weather conditions, including average relative evaporation and groundwater levels

Year	*Number of farms*	*Relative evaporation*	*Ground water level*[1]	*Measured nitrate concentration*	*Corrected nitrate concentration*
2007	141	1.3	137	60	58
2008	141	0.9	146	46	52
2009	142	1.0	161	41	44
2010	143	1.4	147	49	42
2011	142	1.3	149	40	37
2012	147	1.0	144	36	40
2013	151	1.0	153	38	41

[1] Average groundwater level in centimetres below surface level

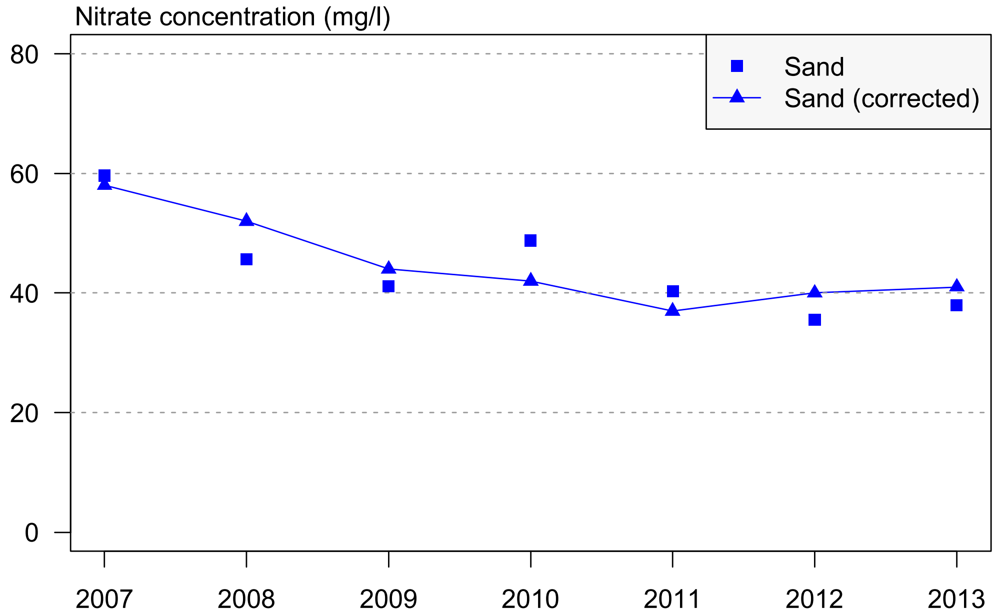

Figure 4.15 Development of uncorrected and corrected nitrate concentrations in water leaching from the root zone in the Sand Region in successive measurement years

With respect to nitrate concentrations in water leaching from the root zone in the Clay Region, no clear relationship with the precipitation surplus or the groundwater level has been found using the correction method originally developed for the Sand Region. This is partly due to the low nitrate concentrations, which make it more difficult to establish clear relationships. In addition, groundwater level data are not available for all farms, so that no corrected concentration data can be provided. Nitrate concentrations in the Peat Region were still lower, making it even more difficult to establish clear relationships. The sample for the Loess Region was too small to perform such a correction.

4.3 Effects of agricultural practices on water quality

The nitrogen soil surpluses in each region did not change during the measurement period, although the nitrate concentrations did decrease in all regions. As the nitrogen soil surplus did not decrease during the measurement period, there must be other causes for the declining nitrate concentrations.

One possible explanation is a decrease in grazing during the measurement period. The trend in dairy farming points to a steady increase in scale and intensification of milk production per hectare and per cow. In addition, more and more farmers are opting to keep their dairy cows in stables full-time, resulting in a decreasing proportion of farms with grazing dairy cows (see Figure 4.3 and section 4.1.1). This trend in grazing may partly explain the decreasing nitrate concentrations in the Sand Region (Boumans and Fraters, 2011). The percentage of dairy farms where dairy cows are kept in stables during the September-October period has shown a notable increase, from 13 percent in 2006 to 25 percent in 2012. The risk of nitrate leaching is particularly high in autumn due to the higher precipitation surplus and lower nitrogen absorption by crops. However, the percentage of farms where cows graze in autumn increased in 2012 compared to 2011.

After-effects may offer another explanation for decreasing nitrate concentrations when the soil surplus remains the same. The soil surplus is based on a balance between input and output. Further nitrogen input from the soil is not included in the soil surplus. Because after-effects can remain noticeable for up to four years (Verloop, 2013), they can only play a role at the start of the measurement period.

Phosphate
The phosphate surplus on the soil surface balance displayed a downward trend. The phosphorus concentrations in water leaching from the root zone in the Clay Region also displayed a significant downward trend. It is unclear if this is caused by decreasing phosphorus surpluses.

The impact of the changes in the phosphorus soil surplus on phosphorus concentrations is unclear because phosphate bonds strongly to the soil, so that any changes in the phosphate surplus have less effect on phosphorus concentrations. It is also possible that phosphorus concentrations in water leaching from the root zone and in ditch water have increased as a result of high groundwater levels and/or more surface runoff.

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Websites
- Agricultural Census data on Statistics Netherlands website: http://statline.cbs.nl
- Koeien & Kansen website: http://www.koeienenkansen.nl

Appendix 1 Selection and recruitment of participants in the derogation monitoring network

A1.1 Introduction

This appendix explains the selection and recruitment of the 300 dairy and other grassland farms participating in the derogation monitoring network. As stated in the main text, the derogation monitoring network has been incorporated into the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM). The selection and recruitment of farms for the derogation monitoring network is comparable to the selection and recruitment of participants in other parts of the LMM programme. Based on the most recent Agricultural Census data at the time (2005), a sample population was defined for each of the four regions. These sample populations were then subdivided into groups of farms ('strata') belonging to the same groundwater body and of the same farm type and economic size. Based on this distribution, the required number of sampled farms was derived for each stratum, taking into account the proportion of the total surface area of cultivated land in a given stratum (the greater the proportion of cultivated land in a stratum, the greater the number of farms to be included in the sample), as well as a minimum representation for each groundwater body.

Recruitment was initially targeted at farms participating in the Farm Accountancy Data Network (FADN; report year 2006). All suitable FADN farms that had registered for derogation in 2006 were approached. After the FADN farms had been recruited, it was determined which strata needed additional farms. Additional farms were selected from a database maintained by the National Service for the Implementation of Regulations of the Ministry of Agriculture, Nature & Food Quality. This database includes all farms that registered for derogation in 2006. Fifteen of the additional participants thus selected also participate in the 'Koeien & Kansen' research project (see www.koeienenkansen.nl).

Replacements for farms that dropped out during the 2006-2012 period were preferably selected from farms that already participated in the LMM programme and the FADN network. The advantage of this approach is that water quality samples and/or agricultural practice data from previous years are also available for farms newly admitted to the derogation monitoring network.

A1.2 Definition of the sample populations

As with the LMM programme, the sample excludes a small number of farms that had registered for derogation and were included in the Agricultural Census database. The first group of farms excluded from participation in the derogation monitoring network comprises very small farms with an economic size of less than 25,000 Standard Output (SO) units. Farms using organic production methods were also excluded. By definition, these organic farms may not use more than 170 kg of nitrogen from livestock manure per hectare (irrespective of the percentage of grassland or the type of fertiliser). Also, a minimum farm size of 10 hectares of cultivated land was adopted to ensure representativeness with respect to surface area. Finally, only farms where grassland makes up at least 70 percent of the total area of cultivated land were taken into consideration for derogation monitoring purposes.

The consequences of these selection criteria are illustrated in Tables A1.1 and A1.2. Table A1.1 (farms) and Table A1.2 (acreages) specify how the sample population has been derived from 2012 Agricultural Census data and a database maintained by the National Service for the Implementation of Regulations. This database contains over 21,700 so-called 'BRS numbers' of farms which registered for derogation for 2012. BRS numbers are the registration numbers of farms registered with the National Service for the Implementation of Regulations. As 876 BRS numbers did not appear in the 2012 Agricultural Census, it was decided not to include absolute numbers of farms and hectares in the tables. Instead, the numbers of excluded farms and hectares of cultivated land are expressed as a percentage of the nearly 21,000 farms for which data were available in the 2012 Agricultural Census.

Table A1.1 Proportion of dairy and other grassland farms (in percentages) represented in the sample population of the derogation monitoring network in 2012

	Distribution of farms		
	Dairy farms	*Other grassland farms*	*Total*
All farms registered for derogation in 2012	71.3%	28.7%	100.0%
Farms smaller than 25,000 SO units	0.04%	12.4%	12.4%
Organic farms	0.3%	0.2%	0.5%
Farms smaller than 10 hectares	0.7%	1.2%	1.9%
Farms where grassland makes up less than 60 percent of cultivated land	0.1%	0.1%	0.2%
Sample population	70.2%	14.9%	85.1%

Source: Statistics Netherlands Agricultural Census 2012, data processed by LEI

Table A1.2 Proportion of cultivated land (in percentages) on dairy and other grassland farms represented in the sample population of the derogation monitoring network in 2012

	Distribution of acreage of cultivated land		
	Dairy farms	*Other grassland farms*	*Total*
All farms registered for derogation in 2012	85.9%	14.1%	100.0%
Farms smaller than 25,000 SO units	0.0%	2.5%	2.5%
Organic farms	0.3%	0.2%	0.5%
Farms smaller than 10 hectares	0.1%	0.2%	0.3%
Farms where grassland makes up less than 60 percent of cultivated land	0.1%	0.1%	0.2%
Sample population	85.3%	11.1%	96.4%

Source: Statistics Netherlands Agricultural Census 2012, data processed by LEI

Tables A1.1 and A1.2 show that specialised dairy farms account for 71.3 percent of all farms that registered for the 2012 derogation scheme, and account for

85.9 percent of the total acreage of cultivated land. Almost all dairy farms also fulfilled the selection criteria used to define the sample population for the derogation monitoring network. The excluded farms are mainly other grassland farms with a small economic size (as expressed in SO units) and a small area of cultivated land. Under the adopted selection criteria, nearly 15 percent of all farms registered for derogation are excluded from the sample population. However, these farms account for just 3.6 percent of the total acreage for which farmers have requested derogation.

A1.3 Notes on individual stratification variables

The derogation decision calls for a monitoring network that is representative of all soil types, fertilisation practices and crop rotations (see Article 8 of the derogation decision). When the derogation monitoring network was designed, the stratification was therefore based on region, as well as farm type, economic size (size class) and groundwater body. As of 2012, stratification based on groundwater body was replaced by stratification based on sub-region. These stratification variables are explained below.

A1.4 Classification according to farm type

Since 2011, the LMM Programme has used Standard Output (SO) units as a measure of the economic size of farms. This unit replaces the previously used Dutch Size Unit (*Nederlandse Grootte-Eenheid*, NGE) (Van der Veen *et al.*, 2012). The Standard Output of a crop, animal product or other agricultural product is its average monetary value based on the prices received by the agricultural entrepreneur, expressed in euros per hectare or animal. A regional SO coefficient for each product has been defined as the average value during a specific reference period (five years). The Netherlands is regarded as a single region for this purpose. The total Standard Output of a farm (i.e. the sum of all SOs per hectare of cultivated crops and per animal) is a measure of its total economic size, expressed in euros.
A farm is characterised as ‘specialised’ when a particular agricultural activity (e.g. dairy farming, arable farming or pig farming) accounts for a major proportion (often at least two-thirds) of its total economic size. Eight main farm types can be distinguished. Five of these types concern one single activity, while three types concern a combination of activities. The five single-activity farm types are: arable farming, horticulture, permanent crops (fruit growing and tree nurseries), grazing livestock, and intensive livestock farming. The three combined-activity farm types are: crop combinations, livestock combinations, and crop and livestock combinations. Each main farm type is further divided into a number of subtypes. For instance, the subcategory of specialised dairy farms is part of the overall category of grazing livestock farms.

Within the group of farms that registered for derogation, dairy farms form a large and homogeneous group, which uses almost 86 percent of the total acreage of cultivated land, as is apparent from Table A1.2. Fourteen percent of the acreage is situated on farms of a different type. These farms were also included in the monitoring network in order to obtain a sample with maximum representativeness for the different crop rotations and fertilisation practices. Non-dairy farms account for approx. 29 percent of all farms (Table A1.1). These farms can be of various types, but are described in this report as ‘Other grassland farms’, as most of the cultivated land consists of grassland.

A1.5 Classification according to economic size

Farms are not only classified by type but also according to economic size, with four size classes being distinguished. This prevents over-representation of farms of below-average or above-average economic size.
Economic size is also expressed in SO units.

A1.6 Classification according to soil type region and sub-region

The Netherlands has been divided into four soil type regions as part of the Minerals Policy Monitoring Programme. The regions are further subdivided into a number of sub-regions. Fourteen sub-regions were defined in total, based on four-digit postcode districts. The participants in the derogation monitoring network have been selected with a view to achieving optimal distribution and representation in each region, in order to cover the most important sub-regions in terms of the area of cultivated land.

In the Sand Region, seven sub-regions were distinguished: Peat Districts, Northern Sand I, Northern Sand II, Eastern Sand, Central Sand, Southern Sand, and Dune Areas and Wadden Sea Islands. The Loess Region has no further sub-regions. The Peat Region is divided into two sub-regions: Northern Peatland Pastures and Western Peatland Pastures. The Clay Region is divided into four sub-regions: Northern Clay, Holland and IJsselmeer Polders, South-Western Marine Clay, and River Clay.

In the 2006-2012 period, stratification was based on groundwater body within the regions (Verhagen *et al.*, 2006). In this period, geographical stratifications (e.g. according to groundwater body) were still based on municipal boundaries. The transition to stratification according to sub-region coincided with the transition from classification based on municipal boundaries to a more accurate classification of regions and sub-regions based on postcode districts.

The Water Framework Directive distinguishes a total of twenty groundwater bodies in the Netherlands (Verhagen *et al.*, 2006). The derogation monitoring network has been designed with a view to achieving optimal distribution and representation in each region, in order to cover the most important groundwater bodies measured in terms of the area of cultivated land. Each farm was assigned to a groundwater body based on the municipality where the farm receives post. In municipalities with multiple groundwater bodies, all farms were assigned to the largest groundwater body.

In the Sand Region, five groundwater bodies were distinguished as sub-regions: Eems, Maas, Rhine Central, Rhine North and Rhine East. Other farms belonging to other groundwater bodies within the region were assigned to a sixth sub-region termed ‘Other’. The Loess Region only contains the ‘Cretaceous’ groundwater body, and was therefore not subjected to further subdivision. The Peat Region was divided into four sub-regions, namely the groundwater bodies Rhine North, Rhine East, Rhine West and ‘Other’. The Clay Region was divided into five sub-regions. The entire marine clay area in the south-west of the Netherlands was classified as a separate sub-region, as it includes multiple groundwater bodies without one body being clearly dominant. A further three groundwater bodies were distinguished as separate sub-regions: Eems, Rhine North and Rhine West (in so far as the latter is located outside the marine clay area in the south-west of the Netherlands). The fifth sub-region includes farms in other, unallocated municipalities.

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Appendix 2 Monitoring of agricultural characteristics

This appendix explains how the agricultural practice data in the FADN network maintained by the Agricultural Economics Research Institute (LEI) were monitored, and how these data were used to calculate fertiliser usage (section A2.2), grass and silage maize yields (section A2.3), and nutrient surpluses (section A2.4).

A2.1 Introduction

LEI is responsible for monitoring the agricultural practice data registered in the FADN network. It does so on the basis of a stratified sample of approx. 1500 farms and horticultural enterprises, maintaining a set of detailed financial, economic and environmental data. The FADN represents nearly 95 percent of all agricultural production in the Netherlands (Poppe, 2004; FADN, 2013). Approx. 45 full-time LEI employees are charged with collecting and registering farm data in FADN. They process all the invoices of the participating farms. They also produce inventories of initial and final stocks and gather additional data on crop rotations, grazing systems, and the composition of the livestock population. LEI sends participants a so-called participant's report containing mainly annual totals (e.g. a profit-and-loss account and balance sheet). When data are processed to produce information for participants or researchers, the results are of course checked for inconsistencies. This is possible because the system also records physical flows in addition to financial flows.

Most FADN data are converted into annual totals, which are then corrected for stock mutations. For example, the annual consumption of feed concentrate is derived from the sum of all purchases made during the period between two balance sheet dates, minus all sales, plus initial stocks, minus final stocks. Fertiliser usage is registered for each crop, and the data allow for calculations of usage per year and per growing season. The growing season extends from the harvesting of the previous crop to the harvesting of the current crop.

Fertiliser usage, yields and nutrient surpluses are expressed per unit of surface area. The total acreage of cultivated land is used for this purpose, i.e. the land actually fertilised and used for crop cultivation at the farm. This acreage does not include rented land, nature areas, ditches, built-up land, paved surfaces, and grassland not used for the production of fodder (e.g. yards, camping sites).

A2.2 Calculation of fertiliser usage

The derogation decision (EU, 2005) stipulates that the report should include details of fertiliser usage and crop yields (Article 10, paragraph 4). This Article states (see section 1.3): "In order to provide elements regarding management in grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the competent authority and submitted to the Commission."

Nutrient usage data are presented by region (Clay, Peat, Sand and Loess Regions). Fertiliser use at farm level is reported, and a distinction is made between use of fertilisers on arable land and on grassland.

A2.2.1 Calculation of fertiliser use

On-farm use of livestock manure
In order to calculate the use of nutrients in livestock manure, on-farm production of manure is calculated first. In the case of nitrogen, this concerns net production after deducting gaseous emissions resulting from stabling and storage. Manure production by grazing livestock is calculated by multiplying the average number of animals present by the applicable statutory excretion standards (National Service for the Implementation of Regulations, 2013, Tables 4 and 6). This method does not apply to farms that use the guidance document issued for this purpose (see the section below headed 'Farm-specific use of livestock manure'). Manure production by intensive livestock is calculated by taking the feedstuff and animal inputs and deducting the outputs of animals and animal products, according to the method described by Groenestein et al. (2008). The calculations make use of the standard quantities provided in Tables 7, 8 and 9 (National Service for the Implementation of Regulations, 2013).

In addition, the quantities are registered for all fertiliser inputs and outputs and all fertiliser stocks (inorganic fertilisers, livestock manure and other organic fertilisers). The nitrogen and phosphate quantities in inorganic fertilisers and other organic fertilisers are derived from the annual overviews of suppliers. If no specific delivery details are known, the quantities are multiplied with factors derived from a standard composition (Nutrient Management Institute, 2013).

In principle, the nitrogen and phosphate quantities in inputs and outputs of organic fertilisers are determined by means of sampling. If sampling has not been performed, standard contents for each type of fertiliser are used (National Service for the Implementation of Regulations, 2013, Table 5). If no sampling results are available, the standard contents for outputs of on-farm manure (National Service for the Implementation of Regulations, 2013, Table 5) are corrected to account for farm-specific manure production. For example, if application of the farm-specific excretion (BEX) method produces an excretion of 90 percent of the standard excretion quantity, outputs of on-farm manure are estimated at 90 percent of the quantity calculated using the standard contents in the aforementioned Table 5 (National Service for the Implementation of Regulations, 2013). This method is applied to both nitrogen and phosphate contents. The standard quantities stated in Table 5 are used if the BEX method is not applied. Initial and closing stocks are always calculated based on standard quantities (National Service for the Implementation of Regulations, 2013, Table 5).

The total quantity of fertiliser used at farm level is then calculated using the following formula:

Quantity of fertiliser used on farm =
Production + Opening stock level – Closing stock level + Input – Output

Farm-specific use of livestock manure
As of agricultural practice year 2007, the calculation method for manure production has been modified for farms that make use of the guidance document on farm-specific excretion by dairy cattle (Ministry of Agriculture, Nature & Food Quality, 2010). Manure production on these farms is not calculated on the basis

of standard quantities but separately for each farm, provided the following criteria are fulfilled:

- The farm is a specialised dairy farm according to the Standard Output classification.
- The dairy herd accounts for at least 67 percent of the total quantity of phosphate LSUs for grazing livestock.
- No pigs or poultry are present on the farm.
- At least 80 percent of the acreage is devoted to the cultivation of fodder crops.
- The farm itself has reported that it uses the BEX method.

As of 1 January 2009, the guidance document on farm-specific excretion by dairy cattle is used to calculate the farm-specific excretion of the dairy herd (Ministry of Agriculture, Nature & Food Quality, 2010). The calculation method used deviates from the guidance document in two respects (Ministry of Agriculture, Nature & Food Quality, 2010):

- The uptake from silage maize expressed in fodder units (*Voeder Eenheden Melk*, VEM) is derived directly from the silage maize yields reported by the farmer, corrected for stocks (the same method used in Aarts *et al.*, 2008). In the guidance document, the uptake is calculated using a correction method.
- The allocation of fodder units to fresh and conserved grass is calculated based on the net number of grazing hours reported by the farmer, whereas the guidance document (Ministry of Agriculture, Nature & Food Quality, 2010) and Aarts *et al.* (2008) define three classes based on reported grazing hours.

Use of fertilisers on arable land and grassland

The quantities of fertilisers used on arable land are registered directly in the Farm Accountancy Data Network (FADN). The type of fertiliser, quantity applied, and time of application are all documented.

The quantities of nitrogen and phosphate applied on arable land are calculated by multiplying the quantity of manure (in tonnes or cubic metres) by:

- the contents derived from sampling results (if available), or
- the applicable standard contents (National Service for the Implementation of Regulations, 2013, Table 5), corrected for farm-specific production (see above) if manure production is calculated separately for each farm (see below), or
- the applicable uncorrected standard contents (National Service for the Implementation of Regulations, 2013, Table 5).

The quantity of fertiliser applied on grassland is calculated as the closing entry: Fertiliser use on grassland = Fertiliser use at farm level -/- Fertiliser use on arable land. In the case of farms where grassland accounts for less than 25 percent of the total cultivated area,[1] fertiliser use on grassland is calculated based on allocations, and the fertiliser use on arable land is calculated as the closing entry. The quantity of fertiliser used on grassland comprises spread fertilisers and manure excreted directly by grazing animals on grassland (grassland manure). The quantity of nutrients in grassland manure is calculated

[1] Not relevant for this report, as farms must be comprised of at least 70 percent grassland to qualify for participation in the derogation scheme.

for each animal category by multiplying the percentage of a year that the animals spend grazing by the standard of excretion.

Use of plant-available nitrogen
The total nitrogen use is expressed in kilogrammes of plant-available nitrogen. The quantity of plant-available nitrogen is calculated by multiplying the total quantity of nitrogen in organic fertilisers by the availability coefficients as stated in Table 3 (National Service for the Implementation of Regulations, 2013, Table 3).

The availability coefficient is lower (45 percent instead of 60 percent since 2008) for all grazing livestock manure produced and applied on the farm if dairy cows graze on the farm. A lower statutory availability coefficient is used if arable land on clay and peat soils is fertilised in autumn using solid manure. In all other cases, the availability coefficient depends solely on the type of fertiliser or manure.

Phosphate use
Phosphate use is expressed in kilogrammes of phosphate. All fertilisers (inorganic fertilisers, livestock manure and other organic fertilisers) are included in the calculation.

Application standards
The average application standards for grassland and arable land are calculated by multiplying the crop areas registered in FADN by the application standards stated in Tables 1 and 2 (National Service for the Implementation of Regulations, 2013, Tables 1 and 2). Phosphate differentiation has been applicable since 2010 (depending on the phosphate status of the soil). Soil test results are registered in FADN in order to determine the phosphate status of the soil. If the phosphate status is unknown, a high phosphate status is assumed by default.

A2.2.2 Lower and upper limits
On LMM farms, fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals in order to eliminate any data registration errors. This applies to the separate quantities of nitrogen and phosphate, as well as the total quantities of fertilisers applied (i.e. inorganic fertilisers, livestock manure, and other organic fertilisers). Table A2.1 lists the confidence intervals for non-organic dairy farms.

Table A2.1 Lower and upper limits for applied quantities of inorganic fertilisers, livestock manure and other organic fertilisers on non-organic dairy farms, and total quantities of fertilisers applied (inorganic fertilisers, livestock manure and other organic fertilisers), expressed in kilogrammes of nitrogen and phosphate per hectare[1, 2]

Nutrient and type	*Lower or upper limit*	*Kg per hectare*
Nitrogen		
Inorganic fertilisers	Lower limit	0
Inorganic fertilisers	Upper limit	400
Livestock manure	Lower limit	100
Livestock manure	Lower limit	0
Livestock manure	Upper limit	500
Other organic fertilisers	Lower limit	0
Other organic fertilisers	Upper limit	400
Total fertiliser use	Lower limit	50
Total fertiliser use	Upper limit	700
Phosphate		
Inorganic fertilisers	Lower limit	0
Inorganic fertilisers	Upper limit	160
Livestock manure	Lower limit	0
Livestock manure	Upper limit	250
Other organic fertilisers	Lower limit	0
Other organic fertilisers	Upper limit	200
Total fertiliser use	Lower limit	25
Total fertiliser use	Upper limit	350

[1] If a value falls outside the upper and lower limits listed in Table A2.1, the mineral flows of the relevant farm are considered incomplete and the farm is not included in the calculation of nutrient flows.

[2] This table only states the lower and upper limits for fertiliser use at farm level on non-organic dairy farms. Other limits are applicable to other types of farms. Lower and upper limits are also applicable to other quantities and indicators.

A2.3 Calculation of grass and silage maize yields

A2.3.1 Calculation procedure

The procedure for calculating grass and silage maize yields in FADN is largely identical to the procedure described in Aarts *et al.* (2005, 2008). The procedure starts by determining the energy requirement of the dairy herd based on milk production and growth achieved. All transactions and stock changes of feed products are registered in FADN. These data are used to determine the proportion of the energy requirement covered by purchased feedstuffs. The energy uptake from farm-produced silage maize and other fodder crops (other than grass) is then determined based on measurements and data on silage supplies, insofar as these are available. The silage maize yield is determined by adding conservation losses to the ensilaged quantity of silage maize. If no reliable silage supply measurements can be obtained, the farmer and/or a consultant is asked to provide an estimate of the yields of farm-produced silage maize and other fodder crops.

It is then assumed that the remaining energy requirement is covered by grass produced on the farm. The number of grazing days registered in FADN is used to calculate a ratio between the energy uptake from fresh grass and the uptake from conserved grass. This procedure can be used to determine the quantity of energy (expressed in fodder units) obtained by the animals from farm-produced feed. The nitrogen (N) and phosphate (P) uptake are then calculated by multiplying the uptake in fodder units (VEMs) by the N:VEM and P:VEM ratios. Finally, the N, P, kVEM and dry matter yields for grassland are calculated by adding to the uptake the average quantity of N, P, kVEMs and dry matter lost during feed production and conservation.

A2.3.2 *Selection criteria*

The above calculation procedure cannot be applied to all farms. On mixed farms, it is often difficult to clearly separate the product flows between different production units. Following Aarts *et al.* (2008), the method is therefore only used on farms that satisfy the following criteria:

- The farm is a specialised dairy farm according to the Standard Output classification.
- The dairy herd accounts for at least 67 percent of the total quantity of phosphate LSUs for grazing livestock.
- No pigs or poultry are present on the farm.
- At least 80 percent of the acreage is used for the cultivation of fodder crops.
- The so-called 'countryside premium' (compensation for land on which the farmer has accepted restrictions to protect nature) does not exceed 100 euros per hectare of grassland.

The following selection criteria for application of the method were <u>not</u> adopted from Aarts *et al.* (2008):

- At least 15 hectares used for cultivation of fodder crops
- At least 30 dairy cows
- Annual milk production of at least 4,500 kg of Fat and Protein Corrected Milk (FPCM) per cow
- Non-organic production method

These criteria were not considered because they were used in Aarts *et al.* (2008) to make statements about the population of 'typical' dairy farms. These criteria can be ignored because the population details have already been registered in the permanent derogation monitoring network (comprising 300 farms). In line with Aarts *et al.* (2008), the following additional confidence intervals for yields were applied with respect to the outcomes:

- Silage maize yield of 5,000 to 22,000 kg of dry matter per hectare
- Grassland yield of 4,000 to 20,000 kg of dry matter per hectare

If the yield falls outside this range, it is assumed that this must be caused by a bookkeeping error. In that case, the farms concerned are also excluded from the report.

A2.3.3 *Deviations from Aarts et al. (2008)*

In a few cases, we deviated from the procedure described in Aarts *et al.* (2005, 2008) because more detailed information was available, or because the procedure could not be properly incorporated into FADN. This concerns the following data:

1. Composition of silage grass and silage maize pits
2. Supplement for grazing based on actual number of grazing days
3. Ratio of conserved grass to fresh grass, based on the actual number of grazing days
4. Conservation and feed production losses

Re 1
Aarts *et al.* (2008) base the composition of silage grass and silage maize pits on provincial averages supplied by the Netherlands Laboratory for Soil and Crop Research (BLGG). A slightly different method is used in FADN. Since 2006, the composition of silage grass and silage maize pits per farm is also registered in FADN. The FADN calculation procedure uses these farm-specific composition data if at least 80 percent of all silage pits have been fully sampled. The average pit composition for each soil type is used if less than 80 percent of pits have been sampled and/or if data are missing (i.e. dry matter yields, VEM uptake, nitrogen or phosphate content). Data on average silage grass and silage maize pit composition are obtained annually from BLGG.

Re 2
A so-called 'mobility factor' is taken into account when calculating the energy requirement. This factor depends on the number of grazing days, among other things. Aarts *et al.* (2008) distinguish three grazing categories: no grazing (0 grazing days), fewer than 138 grazing days, and more than 138 grazing days. The numbers of grazing days have been registered in FADN since 2004 and it was decided to use these data for the calculation, in accordance with Appendix 2 to the guidance document (Ministry of Agriculture, Nature & Food Quality, 2010).

Re 3
Deviating from Aarts *et al.* (2008), the ratio of energy uptake from fresh grass vs. uptake from silage grass was calculated based on the number of grazing days and/or 'zero grazing' days registered in FADN. The percentage of fresh grass varies between 0 and 35 percent for zero grazing, between 0 and 40 percent for unlimited grazing, and between 0 and 20 percent for limited grazing. This calculation is also performed in accordance with the method described in Appendix 2 to the guidance document (Ministry of Agriculture, Nature & Food Quality, 2009).

Re 4
The information in Appendix III in Aarts *et al.* (2008) is not complete with respect to the percentages adopted for conservation losses. To avoid any misunderstandings, all percentages used in FADN to calculate conservation and feed production losses are stated in Table A2.2.

Table A2.2 Percentages used for calculation of conservation and feed production losses

	Conservation losses				*Feed production losses*
Category	*Dry matter*	*VEM*	*N*	*P*	*Dry matter, VEM, N and P*
Wet by-products	4	6	1.5	0	2
Additional roughage consumed	10	9.5	2	0	5
Feed concentrate	0	0	0	0	2
Milk products	0	0	0	0	2
Silage maize	4	4	1	0	5
Silage grass	10	15	3	0	5
Meadow grass	0	0	0	0	0
Minerals	0	0	0	0	2

A2.4 Calculation of nutrient surpluses

In addition to fertiliser use and crop yields, the report also includes nitrogen and phosphate surpluses on the soil surface balance (in kg of nitrogen and P2O5 per hectare). These surpluses are calculated by applying a method derived from the approach used and described by Schröder et al. (2004, 2007). This means that, alongside the input quantities of nitrogen and phosphate in organic and inorganic fertilisers and the output quantities in crops, allowance is also made for other sources of input, such as net mineralisation of organic substances in the soil, nitrogen fixation by leguminous plants, and atmospheric deposition.

A state of equilibrium is assumed when calculating nutrient surpluses on the soil surface balance. It is assumed that, in the long term, the input of organic nitrogen in the form of crop residues and organic manure is equal to the annual decomposition. An exception to this rule is made for peat soils and reclaimed peat subsoils (‘*dalgronden*’). With these types of soil, an input due to mineralisation is taken into account: 160 kg of nitrogen per hectare for grassland on peat soils, and 20 kg of nitrogen per hectare for grassland or other crops on peat soils and reclaimed peat subsoils. It is known that net mineralisation occurs in these soils as a result of groundwater level management, which is necessary in order to use the land for cultivation. Schröder *et al.* (2004, 2007) calculate the surplus on the soil surface balance by using the release of nutrients to the soil as a starting point. In this study, a method was employed that uses farm data to calculate the surplus on the soil surface balance.

The calculation method used to determine the nitrogen surplus is summarised in Table A2.3. The surplus on the farm gate balance is first calculated by determining the total input and output of nutrients as registered in the farm records. Stock changes are taken into account when calculating this surplus.

The calculated nitrogen surplus on the farm gate balance is then corrected to account for input and output items on the soil surface balance. The phosphate surplus on the soil surface balance is equal to the surplus on the farm gate balance. A more detailed explanation of the calculation methods can be found in Table A2.3 below.

Table A2.3 Calculation methods used to determine the nitrogen surplus on the soil surface balance (kg of nitrogen per hectare per year)

Description of items		*Calculation method* *Quantity*	*Contents*
Farm inputs	Inorganic fertilisers	Balance of all inputs, outputs and stock changes of inorganic fertilisers	Data obtained from suppliers' annual overviews. If these are not available, standards are used (Nutrient Management Institute, 2013).
	Livestock manure and other organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net consumption (input)	Sampling results or standard quantities (National Service for the Implementation of Regulations, 2013, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section A3.2).
	Feedstuffs	Balance of all input and stock decreases of all feed products (feed concentrate, roughage, etc.)	Data obtained from suppliers' annual overviews. If these are not available, standards are used (Centraal Veevoederbureau, 2012). Standards for compound feed in 2006-2009 based on Statistics Netherlands data (2010, 2011). As of 2010, all compound feed data are calculated for each separate farm. Standards for silage grass and silage maize are based on annual averages for different soil type regions (data supplied by the Netherlands Laboratory for Soil and Crop Research).
	Animals	Only imported animals	Standard quantities based on Ministry of Agriculture, Nature & Food Quality (2010) and National Service for the Implementation of Regulations (2013, Table 7)
	Plant products (sowing seeds, young plants and propagating material)	Only imported plant products	Standard quantities based on Van Dijk, 2003
	Other	Balance of all inputs, outputs and stock changes of all other	Standards based on Internet search queries

		products in the case of net consumption (input)	
Farm outputs	Animal products (milk, wool, eggs)	Balance of all inputs, outputs and stock changes of all milk and other animal products	Standard quantities based on Ministry of Agriculture, Nature & Food Quality (2010) and National Service for the Implementation of Regulations (2013, Tables 7 and 8)
	Animals	Balance of outputs and stock changes of animals and meat	Standard quantities based on Ministry of Agriculture, Nature & Food Quality (2010) and National Service for the Implementation of Regulations (2013, Tables 7 and 8)
	Livestock manure and other organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net production (output)	Sampling results or standard quantities (National Service for the Implementation of Regulations, 2013, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section A3.2).
	Crops and other plant products	Balance of outputs and stock changes of plant products (crops not intended for roughage), stock increases and sales of roughage	Standard quantities based on Van Dijk (2003) and Centraal Veevoederbureau (2012)
	Other	Balance of all inputs, outputs and stock changes of all other products in the case of net production (output)	Standards based on Internet search queries
Nitrogen surplus on farm gate balance		Farm input -/- Farm output	
Input on soil surface balance	+ Mineralisation	For grassland on peat soil: 160 kg of nitrogen per hectare per year. Other crops on peat soils and reclaimed peat subsoils (irrespective of crop): 20 kg of nitrogen per hectare per year. All other soil types: 0 kg. In the case of FADN farms, the surface areas are registered according to the four soil types used by the National Service for the Implementation of Regulations (sand, clay, peat and loess soils). Mineralisation in reclaimed peat subsoils was estimated based on overall soil classifications on each farm (based on postcode), in accordance with De Vries and Denneboom (1992).	

	+ Atmospheric deposition	Atmospheric deposition is determined annually for each province. The basic data are derived from National Institute for Public Health and the Environment, 2013.
	+ Nitrogen fixation by leguminous plants	Clover on grassland (Kringloopwijzer, 2013): the quantity of nitrogen fixation depends on the proportion of clover and the grassland yield, and is expressed per kg of dry matter: 0 to 1 percent clover: 0 kg; 1 to 5 percent clover: 0.03 kg; 5 to 15 percent clover: 0.1 kg; more than 15 percent clover: 0.2 kg. Other crops (Schröder, 2006): - Lucerne: 160 kg per hectare - Peas, broad beans, kidney beans and French beans: 40 kg per hectare - Other leguminous plants: 80 kg per hectare
Output on soil surface balance	- Volatilisation resulting from stabling, storage and grazing	The calculation method is based on Velthof *et al.* (2009). Calculations are based on the Total Ammonia Nitrogen (TAN) percentage. If the farm uses a farm-specific calculation method to calculate manure production, the emissions resulting from grazing, stabling and storage are calculated as follows: - Ammonia emissions resulting from stabling and storage: the stable code under the Ammonia and Livestock Farming Regulations (*Regeling Ammoniak en Veehouderij*, RAV) is used as a starting point. The total nitrogen emissions are calculated as a percentage of the emitted ammonia nitrogen (based on the RAV emission factor). - Ammonia emissions resulting from grazing are calculated as a percentage (3.5 percent) of the total quantity of ammonia nitrogen excreted on grassland. If a farm calculates excretion based on standard quantities, the emissions resulting from grazing, stabling and storage are calculated as follows: - The gross standard-based excretion is calculated by adding the standard-based emission factor to the net standard-based excretion (Oenema *et al.*, 2000). This factor depends on the type of animal (11.3 percent for dairy cows). - The emissions resulting from grazing are then calculated by multiplying the quantity of nitrogen excreted in grassland manure (net standard-based excretion * grassland fraction) by 3.5 percent, and then by the fraction of the total quantity of ammonia nitrogen in manure. - The emissions resulting from stabling and storage are calculated as the gross standard-based excretion minus the net standard-based excretion.
	- Volatilisation resulting from application	The ammonia emission factors for the application of livestock manure and inorganic fertilisers are based on Velthof *et al.* (2009). Other gaseous nitrogen emissions during application are not taken into consideration. Emissions resulting from application are calculated as a percentage of the applied ammonia nitrogen based on the

	emission factors as reported in Appendix 14 in Velthof *et al.* (2009). If no information on the application method is available (this has not been the case in the LMM framework since 2010), a standard for each soil type is applied. This standard is derived using the MAMBO method (De Koeijer *et al.*, 2012). Agricultural Census data on application methods are used for this purpose. The methods are classified according to soil type and land use type and linked to an emission factor and a Total Ammonia Nitrogen (TAN) factor.
Nitrogen surplus on the soil surface balance	Nitrogen surplus on farm + input on soil surface balance – output on soil surface balance

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Appendix 3 Sampling of water on farms in 2012

A3.1 Introduction

The derogation decision (EU 2005, see section 1.3) states that a report must be produced on the development of water quality, and that this report must be based, among other things, on regular monitoring of water leaching from the root zone as well as surface and groundwater quality (Article 10, paragraph 1). The monitoring of the quality of the 'shallow groundwater layers, soil moisture, drainage water and watercourses on farms that are part of the monitoring network' must yield information about the nitrate and phosphorus concentrations in water leaving the root zone and ending up in the groundwater and surface water system (Article 8, paragraph 4).

A3.1.1 Water sampling

In the Netherlands, the groundwater level is often located just below the root zone. The average groundwater level in the Sand Region is approximately 1.5 metres below surface level. The average groundwater level in the Clay and Peat Regions is shallower. The average groundwater level is more than five metres below surface level only in the Loess Region and on the push moraines in the Sand Region. In most situations, therefore, water leaching from the root zone or leaching into groundwater can be analysed by sampling the top metre of phreatic groundwater. In situations where the water table is more than five metres below surface level and the soil retains sufficient moisture (in the Loess Region), the soil moisture below the root zone is sampled. There is little agricultural activity on the push moraines in the Sand Region where the water table is far below the surface. Where these agricultural activities do occur, the soil moisture below the root zone is sampled if possible.

The surface water is loaded with nitrogen and phosphorus via run-off and groundwater. In the latter case, the travel times are usually longer. In the High Netherlands, only water leaching from the root zone is monitored by sampling the top metre of groundwater or by sampling soil moisture below the root zone. In areas drained by means of ditches in the Low Netherlands (possibly in combination with tile drainage), the travel times are shorter. Here, the loading of surface water is analysed by sampling ditch water, the top metre of groundwater, and/or water from tile drainage (drain water).

A3.1.2 Number of measurements per farm

On each farm, groundwater, soil moisture and drain water were sampled at sixteen locations, while ditch water was sampled at up to eight locations. The number of measurement locations was based on the results of previous research carried out in the Sand Region (Fraters *et al.*, 1998; Boumans *et al.*, 1997), in the Clay Region (Meinardi and Van den Eertwegh, 1995, 1997; Rozemeijer *et al.*, 2006) and in the Peat Region (Van den Eertwegh and Van Beek, 2004; Van Beek *et al.*, 2004; Fraters *et al.*, 2002).

A3.1.3 *Measurement period and measurement frequency*

In the Low Netherlands, samples are taken in winter. In this region of the country, shallow groundwater flows in winter transport a significant portion of the precipitation surplus to the surface water. In polders in the dry season, water from outside the polder is often let in to maintain groundwater levels and water levels in ditches. Samples can be taken in summer as well as winter on sand and loess soils in the High Netherlands. As the available sampling capacity must be utilised throughout the year, sampling in the Sand Region is carried out in summer and sampling in the Loess Region in autumn. The measurement period (see Figure A3.1) has been chosen in such a manner that the measurements are properly representative of water leaching from the root zone, and thus reflect as accurately as possible the agricultural practices of the previous year. Due to weather conditions, sampling campaigns may need to be extended or started at a later time.

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Soil moisture in Loess Region												■	■	■	■	
Total groundwater in Sand Region							■	■	■	■	■	■				
Groundwater in Sand Region in Low Netherlands		■	■	■	■	■	■									
Groundwater in Clay Region[1]	■	■	■		■	■										
Groundwater in Peat Region[1]		■	■	■	■	■										
Drain water and ditch water in all regions	■	■	■	■	■	■	■									

[1] The date when sampling starts depends on the quantity of precipitation, as sufficient precipitation must have fallen before leaching into groundwater occurs. Sampling never starts later than 1 December.

Figure A3.1 Overview of standard sampling periods for determining water quality in each region

In the High Netherlands, groundwater and soil moisture are sampled once a year on each farm. The annual precipitation surplus in the Netherlands amounts to approx. 300 mm. This quantity of water spreads throughout the soil with a porosity of 0.3 (typical for sandy soils) over a soil layer of approx. 1 metre (saturated soil). Therefore, the quality of the top metre of groundwater is representative of the water leaching from the root zone every year, and the loading of the groundwater. Other types of soil (clay, peat, loess) generally have higher porosity. In other words, a sample from the top metre will contain, on average, water from more than just the previous year. A measuring frequency of once every year is therefore sufficient. Previous research has shown that variations in nitrate concentrations during one year and between years can be eliminated when dilution effects and groundwater level variations are taken into account (Fraters *et al.*, 1997).

From the start of the first sampling period in the Low Netherlands after the granting of derogation (1 October 2006), the sampling frequency for drain water and ditch water was increased from two to three rounds per winter period (the LMM sampling frequency until then) to approximately four rounds per winter (intended LMM sampling frequency). This increase in sampling frequency allows for improved distribution during the leaching season. The feasibility of four sampling rounds depends on the weather conditions. It may be impossible to sample drains during periods of frost or insufficient precipitation. The intended LMM sampling frequency was based on research carried out in the early 1990s (Meinardi and Van den Eertwegh, 1995, 1997; Van den Eertwegh, 2002). A review of the LMM programme in the clay areas in the 1996-2002 period produced the conclusion that there was no reason to change the existing relationship between the number of sampling rounds per farm and per year (actual sampling frequency) and the number of drains sampled on each farm and during each sampling round (Rozemeijer *et al.*, 2006). The sampling frequency was increased in response to the European Commission's request.. A frequency of four times a year corresponds to the proposed sampling frequency for operational monitoring of vulnerable phreatic groundwater with a relatively fast and shallow run-off (EU, 2006).

In addition to the compulsory components of nitrate content, total nitrogen content and total phosphorus content, other water quality characteristics were also determined as part of the chemical analysis of water samples. This was done to explain the results of the measurements of the compulsory components. These additional components include ammonium nitrogen, orthophosphate and a number of general characteristics such as conductivity, pH value, and dissolved organic carbon concentration. The results of these additional measurements have not been included in this report.

The sections below describe the sampling procedure for each region in greater detail. The activities were performed in accordance with the applicable work instructions. The text below refers to the applicable work instructions by stating the relevant document number (e.g. BW-W-021). An overview of the work instructions concerned is provided at the end of this appendix.

As far as sampling in the Low Netherlands is concerned, a period of frost in early February 2011 meant that not all drain water and ditch water samples could be taken according to schedule. The schedule was modified slightly to prevent an extension to May 2012.

A3.2 Sand and Loess Regions

A3.2.1 Standard sampling procedure

Groundwater sampling on derogation farms in the Sand Region was carried out from March 2012 to October 2013 (see Figure A3.2). In the Loess Region, samples were taken from September 2012 to January 2013 (see Figure A3.2) Each farm was sampled once during these periods.

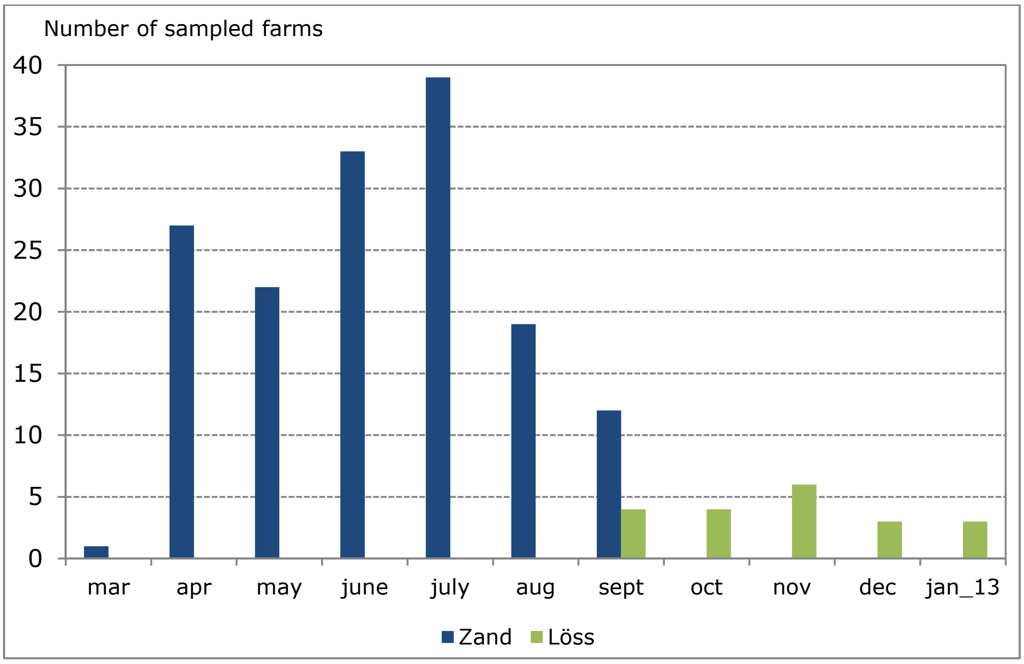

Figure A3.2 Number of farms sampled on groundwater and soil moisturein the Sand and Loess Regions per month during the period from March 2012 to January 2013

The samples were taken in accordance with the standard sampling method. On each farm, samples were taken from bore holes drilled at sixteen locations. The number of locations per plot depended on the size of the plot and the number of plots on each farm. The locations in the plot were selected at random. The locations were selected and positioned in accordance with the applicable protocol (BW-W-021). The top metre of groundwater was sampled using the open bore hole method (BW-W-015). The groundwater levels and nitrate concentrations were determined in situ at each location (Nitrachek method, BW-W-001). The water samples were filtered and stored in a cool dark place prior to transport to the laboratory (BW-W-008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (BW-W-009). Soil moisture samples were taken by collecting drill cores at depths ranging from 150 to 300 cm, using an Edelman drill. The samples were then transported to the laboratory in untreated form and packed in tightly sealed containers (BW-W-014). In the laboratory the samples were centrifuged to collect the soil moisture. In the laboratory two compound samples were prepared (each consisting of eight separate samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

A3.2.2 Additional sampling in low-lying areas

On farms in the Sand Region, additional ditch water samples were taken during the period from October 2011 to April 2012 (see Figure A3.3), in accordance with the standard method. On each farm, up to two types of ditches were distinguished: farm ditches and local ditches. Farm ditches transport water originating on the farm itself. Local ditches carry water from elsewhere, so that the water leaving the farm is a mixture.

If farm ditches were present, samples were taken downstream (i.e. where the water leaves the farm or ditch) in up to four of these ditches. Furthermore, samples were taken downstream in up to four local ditches to gain insight into the local ditch water quality. If there were no farm ditches, then samples were taken both upstream and downstream in four local ditches. This method provides insight into the local water quality and the impact of the farm's activities on water quality. Three types of samples may therefore be distinguished: farm ditch, local ditch (upstream) and local ditch (downstream). The locations for ditch water sampling were selected in accordance with the applicable protocol (BW-W-021). The selection was aimed at gaining insight into the impact of the farm's activities on ditch water quality, and excluding as far as possible any effects external to the farm.

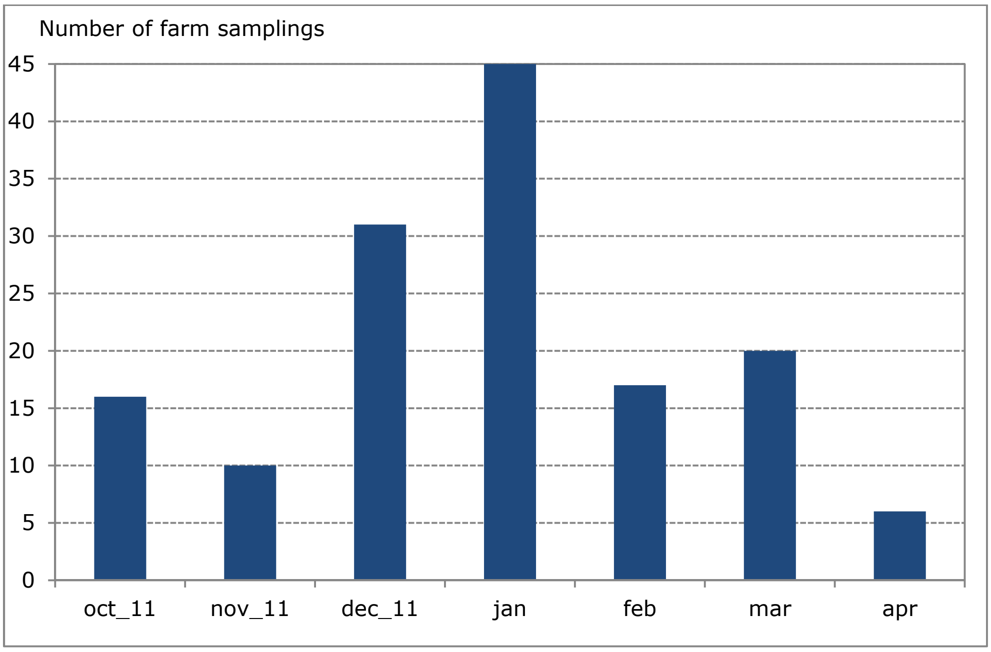

Figure A3.3 Number of farm samplings on ditch water in the Sand Region per month during the period from October 2011 to April 2012

Three to four ditch water samples were taken on these farms in the winter of 2011-2012.

The ditch water samples were taken using a measuring beaker attached to a stick or 'fishing rod' (BW-W-011). Water samples were stored in a cool, dark place prior to transport to the laboratory (BW-W-008). The ditch water samples were filtered in the laboratory on the next day, and two compound samples were prepared (one for each ditch type). The separate ditch water samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen and total phosphorus content.

A3.3 Clay Region

In the Clay Region, a distinction is made between farms where the soil is drained using drainage pipes and farms where this is not the case. A farm is considered to lack drainage if less than 25 percent of its acreage is drained using drainage pipes, or if less than 13 drains can be sampled. Different sampling strategies are employed on farms with drainage and farms without drainage.

A3.3.1 Farms with drainage

On farms with drainage, drain water and ditch water were sampled during the period from October 2011 to April 2012 (see Figure A3.4). On each farm, 16 drainage pipes were selected for sampling. The number of drainage pipes to be sampled on each plot depended on the size of the plot. Within one plot, the drains were selected in accordance with the relevant protocol (BW-W-021). On each farm, two ditch types were distinguished. For each ditch type, up to four sampling locations were selected (see section A3.2). The selection was performed in accordance with the aforementioned protocol, and was aimed at gaining insight into the impact of the farm's activities on ditch water quality, and excluding as far as possible any effects external to the farm.

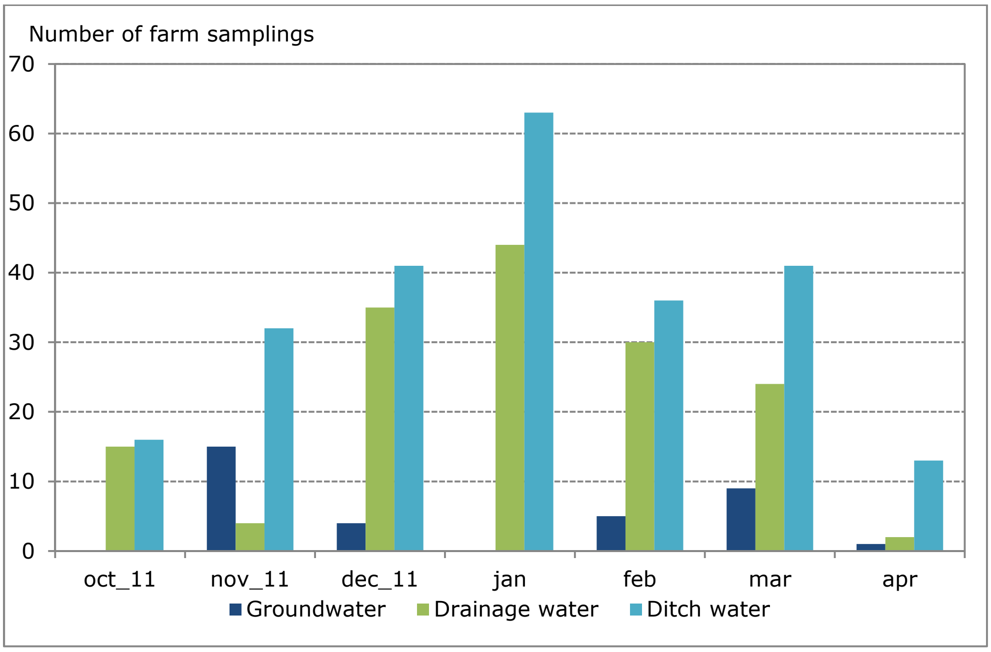

Figure A3.4 Number of farm samplings on groundwater, drain water and ditch water in the Clay Region per month during the period from October 2011 to April 2012

During the winter of 2011/2012, drain water and ditch water were sampled between one and four times using the method described in the previous section. The samples were taken throughout the winter, with a period of at least three weeks elapsing between two samples.

Water samples were stored in a cool, dark place prior to transport to the laboratory (BW-W-008). The next day, one compound sample was prepared from the drain water samples in the laboratory, and two compound samples were prepared from the ditch water samples (one for each ditch type). The separate drain water and ditch water samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen content and total phosphorus content.

A3.3.2 Farms without drainage

On farms without drainage, samples were taken of the top metre of groundwater and ditch water during the period from November 2011 to April 2012 (BW-W-021) (see Figure A3.4). On these farms, the groundwater was sampled one or two times, while the ditch water was sampled one to four times.

The groundwater was sampled using a method comparable to the one used in the Sand Region, with the exception that the groundwater was sampled twice in the Clay Region. However, the closed bore hole method (BW-W-015) was occasionally used instead of the open bore hole method. The nitrate concentration was determined in situ at each of the 16 locations (Nitrachek method, BW-W-001). The water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (BW-W-008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (BW-W-009). In the laboratory, two compound samples were prepared (each consisting of eight individual samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

The ditch water samples were taken in a manner similar to the method deployed on farms with drainage, i.e. two ditch types were defined, with up to four sampling locations per ditch type. However, samples were taken using a filter lance (BW-W-011) and water samples were immediately filtered in situ and analysed for nitrate content (Nitrachek method, BW-W-001). The individual samples were not only filtered, but also conserved (BW-W-009) and stored in a cool, dark place prior to transport to the laboratory (BW-W-008). In the laboratory, one compound sample was prepared for each ditch type. The compound samples were analysed for nitrate content, total nitrogen content, and total phosphorus content.

A3.4 Peat Region

In the Peat Region, the top metre of groundwater was sampled once on all farms during the period from November 2011 to April 2012 (see Figure A3.5). Three to four ditch water samples were taken on these farms in the period from November 2011 to May 2012.

The groundwater was sampled using a method similar to the one employed in the Sand and Clay Regions. However, the reservoir tube method (BW-W-015) was generally used instead of the open or closed bore hole method. The nitrate concentration was determined in situ at each of the 16 locations (Nitrachek method, BW-W-001). The water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (BW-W-008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (BW-W-009). In the laboratory, two compound samples were prepared (each consisting of eight individual samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

The ditch water samples were taken together with the groundwater samples, using a method similar to that used on farms without drainage in the Clay Region. The samples were taken using a filter lance (BW-W-011). Samples were taken at four locations for each of the two ditch types. Water samples were immediately analysed in situ for nitrate content (Nitrachek method, BW-W-001). The individual water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (BW-W-008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (BW-W-009). In the laboratory, two compound samples were prepared from these ditch water samples (one for each ditch type). The compound samples were analysed for nitrate content, total nitrogen content, and total phosphorus content.

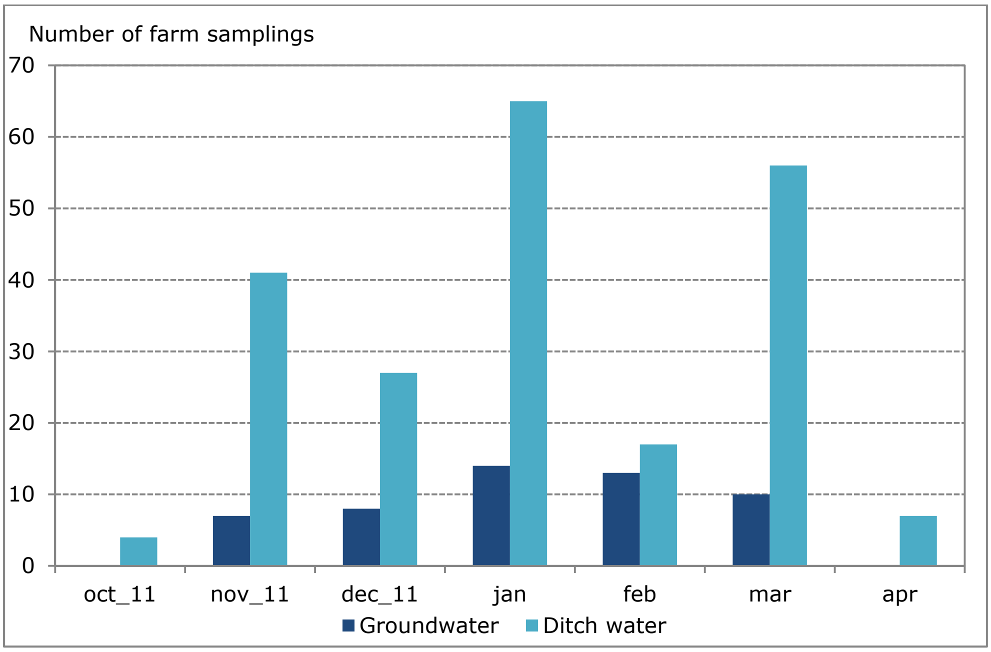

Figure A3.5 Number of farm samplings on groundwater and ditch water in the Peat Region per month during the period from November 2011 to April 2012

The additional ditch water samples were taken at the same locations as the samples that were taken together with the groundwater samples. However, a different sampling method was used, namely the method used on farms with drainage in the Clay Region. Samples were taken using a 'fishing rod' and measuring beaker. No analyses were performed in situ and the samples were stored in a cool, dark place prior to transport to the laboratory (BW-W-011), but not filtered or conserved. On the next day, one compound sample for each ditch type was prepared in the laboratory and analysed for nitrate content, total nitrogen content, and total phosphorus content. Up to four separate samples were combined to prepare a compound sample for each ditch type.

The following RIVM work instructions were used:

BW-W-001	Measuring nitrate concentrations in aqueous solutions using a Nitracheck reflectometer (type 404)
BW-W-008	Temporary storage and transportation of samples
BW-W-009	Method for conserving water samples by adding acid
BW-W-011	Sampling ditch water or surface water using a modified sampling lance and peristaltic pump
BW-W-014	Soil sampling using an Edelman drill for soil moisture analysis purposes

BW-W-015	Groundwater sampling using a sampling lance and peristaltic pump on sand, clay or peat soils
BW-W-021	Determining the sampling locations

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Appendix 4 Derogation monitoring network results by year

Table A4.1A Some general characteristics of farms participating in the derogation monitoring network (DMN) in the 2006-2012 period

Farm characteristic	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Number of dairy farms	251	247	249	249	252	255	262
Number of other grassland farms	43	48	47	44	42	35	33
Total area of cultivated land (hectares)	49	50	51	52	52	53	55
Proportion of grassland (%)	83	83	82	82	83	83	83
Proportion of farms with intensive livestock (%)	12	13	12	10	10	8	6
Total livestock density (Phosphate Livestock Units per hectare)[1]	3.0	3.1	2.7	2.8	2.9	2.8	2.6
Kilogrammes of FPCM per dairy farm (x 1,000)	697	731	783	813	860	869	893
Kilogrammes of FPCM per dairy cow (x 1,000)	8.4	8.4	8.4	8.5	8.7	8.6	8.5
FPCM production per hectare of fodder crop (x 1,000 kg)	14	14	15	15	16	16	16
Percentage of dairy farms where dairy cows graze in May-October period	89	88	86	83	79	78	79
Percentage of dairy farms where dairy cows graze in May-June period	86	84	83	80	76	76	77
Percentage of dairy farms where dairy cows graze in July-August period	88	88	86	83	79	78	79
Percentage of dairy farms where dairy cows graze in September-October period	87	87	84	80	74	71	75

[1] Phosphate Livestock Unit (LSU) is a unit used to compare numbers of animals based on their standard phosphate production. One adult dairy cow produces 41 kg of phosphate on average, which is equivalent to 1 Phosphate LSU. One young animal 1-2 years of age produces 18 kg of phosphate (0.44 Phosphate LSU); one young animal 0-1 years of age produces 9 kg of phosphate (0.22 Phosphate LSU) (source: Ministry of Agriculture, Nature & Food Quality, 2000).

Compared to the reports published in the years up to 2012, some changes in the data for the 2006-2010 period have occurred. In the reports published from 2013 onwards, the number of dairy farms has decreased by 5 to 12 farms and the number of other grassland farms has increased by 5 to 12 farms. The proportion of farms with intensive livestock has decreased by 4 to 6 percentage points in the reports published from 2013 onwards. This is caused by the fact that in 2011 (report published in 2013), the LMM programme started using Standard Output (SO) units instead of Dutch Size Units (*Nederlandse Grootte-Eenheid*, NGE) as the unit of economic size. The new units are applied with retroactive effect. See Appendix 1, section A1.4 for further information.

Table B4.1B Some general characteristics of farms participating in the derogation monitoring network (DMN): average values for the 2006-2011 period, results for 2012, differences between 2012 results and the average values for the 2006-2011 period, and trends identified for the 2006-2012 period (also see Table A4.1A)

Farm characteristic	*Average 2006-2011*	*2012*	*Difference*	*Trend*
Number of dairy farms	251	262		
Number of other grassland farms	43	33		
Total area of cultivated land (hectares)	51	55	+	+
Proportion of grassland (%)	83	83	≈	≈
Proportion of farms with intensive livestock (%)	11	6	-	-
Total livestock density (Phosphate Livestock Units per hectare)[1]	2.9	2.6	≈	-
Kilogrammes of FPCM per farm (x 1,000)	792	893	+	+
Kilogrammes of FPCM per dairy cow (x 1,000)	8.5	8.5	≈	+
FPCM production per hectare of fodder crop (x 1,000 kg)	15	16	+	+
Percentage of dairy farms where dairy cows graze in May-October period	84	79	-	-
Percentage of dairy farms where dairy cows graze in May-June period	81	77	≈	-
Percentage of dairy farms where dairy cows graze in July-August period	84	79	-	-
Percentage of dairy farms where dairy cows graze in September-October period	81	75	-	-

[1] Phosphate Livestock Unit (LSU) is a unit used to compare numbers of animals based on their standard phosphate production.
One adult dairy cow produces 41 kg of phosphate on average, which is equivalent to 1 LSU. One young animal 1-2 years of age produces 18 kg of phosphate (0.44 Phosphate LSU); one young animal 0-1 years of age produces 9 kg of phosphate (0.22 Phosphate LSU) (source: Ministry of Agriculture, Nature & Food Quality, 2000).
Difference: direction and significance of difference between 2012 and average for previous years.
≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2012 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table B4.2A Average nitrogen usage in livestock manure (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2012 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Number of farms	273	278	277	270	276	278	281
Use of nitrogen in livestock manure							
Produced on farm	264	263	269	267	279	277	263
+ Inputs	8	10	10	10	8	11	11
+ Changes in stocks[1]	-4	-8	-7	-1	-8	-6	-5
- Outputs	25	30	32	32	38	36	30
Total use	242	236	240	243	240	246	239
Use on grassland[2]	253	248	257	261	254	259	253
Use on arable land[3]	184	182	174	170	168	179	175

[1] A negative change in stocks is a stock increase and corresponds to output of manure.

[2] The average use on grassland is based on the following numbers of farms: 264 (2006), 270 (2007), 264 (2008), 260 (2009), 262 (2010), 262 (2011) and 268 (2012). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit.

[3] The average use on arable land is based on the following numbers of farms: 196 (2006), 199 (2007), 204 (2008), 199 (2009), 192 (2010), 198 (2011) and 203 (2012). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 9 (2006), 8 (2007), 13 (2008), 10 (2009), 14 (2010), 16 (2011) and 13 (2012). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 60 (2008), 61 (2009), 70 (2010), 64 (2011) and 65 (2012).

Table A4.2B Application of nitrogen in livestock manure (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2011 period, results for 2012, differences between 2012 results and the average values for the 2006-2011 period, and trends identified for the 2006-2012 period (also see Table A4.2A)

Description	*Average 2006-2011*	*2012*	*Difference*	*Trend*
Number of farms	275	281		
Use of nitrogen in livestock manure				
Produced on farm	270	263	≈	≈
+ Inputs	9	11	+	+
+ Changes in stocks[1]	-6	-5	≈	≈
- Outputs	32	30	≈	+
Total use	241	239	≈	≈
Use on grassland	255	253	≈	≈
Use on arable land	176	175	≈	≈

[1] A negative change in stocks is a stock increase and corresponds to output of manure.

Difference: direction and significance of difference between 2012 and average for previous years.

≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).

Trend: direction and significance of trend in 2006-2012 period.

≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.3A Average nitrogen usage (in kg of plant-available nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2012 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Number of farms	273	278	277	270	276	278	281
Livestock manure excluding availability coefficient	242	236	240	243	240	246	239
Availability coefficient	39	40	48	48	49	49	49
Livestock manure including availability coefficient	94	94	115	117	117	122	118
+ Other organic fertilisers	0	0	0	0	0	0	0
+ Inorganic fertilisers	128	127	122	125	124	123	125
Total use	222	221	237	242	241	245	243
Nitrogen application standard applicable to farm	294	285	270	262	259	259	257
Use on grassland[1]	246	246	266	269	266	270	271
Nitrogen application standard for grassland	315	313	294	285	281	281	281
Use on arable land[2]	110	114	123	124	119	126	125
Nitrogen application standard for arable land	156	158	157	153	154	152	145

[1] The average use on grassland is based on the following numbers of farms: 264 (2006), 270 (2007), 264 (2008), 260 (2009), 262 (2010), 262 (2011) and 268 (2012). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit.

[2] The average use on arable land is based on the following numbers of farms: 196 (2006), 199 (2007), 204 (2008), 199 (2009), 192 (2010), 198 (2011) and 203 (2012). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 9 (2006), 8 (2007), 13 (2008), 10 (2009), 14 (2010), 16 (2011) and 13 (2012). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 60 (2008), 61 (2009), 70 (2010), 64 (2011) and 65 (2012).

Table A4.3B Nitrogen usage (in kg of plant-available nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2011 period, results for 2012, differences between 2012 results and the average values for the 2006-2011 period, and trends identified for the 2006-2012 period (also see Table A4.3A)

Description	*Average 2006-2011*	*2012*	*Difference*	*Trend*
Number of farms	275	281		
Livestock manure excluding availability coefficient	241	239	≈	≈
Availability coefficient	46	49	+	+
Livestock manure including availability coefficient	110	118	+	+
+ Other organic fertilisers	0	0	≈	≈
+ Inorganic fertilisers	125	125	≈	≈
Total use	235	243	+	+
Nitrogen application standard applicable to farm	271	257	-	-
Use on grassland	260	271	+	+
Nitrogen application standard for grassland	295	281	-	-
Use on arable land	119	125	+	+
Nitrogen application standard for arable land	155	145	-	-

Difference: direction and significance of difference between 2012 and average for previous years.
≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2012 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.4A Average phosphate usage (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2012 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Number of farms	273	278	277	270	276	278	281
Livestock manure	88	85	88	89	86	86	84
+ Other organic fertilisers	0	0	0	0	0	0	0
+ Inorganic fertilisers	10	7	6	4	3	3	3
Total use	99	93	94	93	89	89	87
Phosphate application standard applicable to farm	108	103	98	98	91	90	89
Use on grassland[1]	100	95	98	96	92	91	90
Phosphate application standard for grassland	111	106	100	101	94	94	93
Use on arable land[2]	91	88	83	78	74	78	76
Phosphate application standard for arable land	95	90	85	85	77	73	68

[1] The average use on grassland is based on the following numbers of farms: 264 (2006), 270 (2007), 264 (2008), 260 (2009), 262 (2010), 262 (2011) and 268 (2012). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit.

[2] The average use on arable land is based on the following numbers of farms: 196 (2006), 199 (2007), 204 (2008), 199 (2009), 192 (2010), 198 (2011) and 203 (2012). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 9 (2006), 8 (2007), 13 (2008), 10 (2009), 14 (2010), 16 (2011) and 13 (2012). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 60 (2008), 61 (2009), 70 (2010), 64 (2011) and 65 (2012).

Table A4.4B Phosphate usage (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2011 period, results for 2012, differences between 2012 results and the average values for the 2006-2011 period, and trends identified for the 2006-2012 period (also see Table A4.4A)

Description	*Average 2006-2011*	*2012*	*Difference*	*Trend*
Number of farms	275	281		
Livestock manure	87	84	-	-
+ Other organic fertilisers	0	0	≈	≈
+ Inorganic fertilisers	5	3	-	-
Total use	93	87	-	-
Phosphate application standard applicable to farm	98	89	-	-
Use on grassland	95	90	-	-
Phosphate application standard for grassland	101	93	-	-
Use on arable land	82	76	-	-
Phosphate application standard for arable land	84	68	-	-

Difference: direction and significance of difference between 2012 and average for previous years.
≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2012 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.5A Crop yields (in kg of dry matter, nitrogen, phosphorus and P_2O_5 per hectare) for grassland (calculated) and silage maize (estimated) on farms participating in the derogation monitoring network that meet the criteria for application of the grassland yield calculation method (Aarts et al., 2008), during the 2006-2012 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Estimated silage maize yield							
Number of farms	152	142	151	164	162	165	160
Tonnes of dry matter per hectare	15	15	16	16	16	16	17
Kilogrammes of nitrogen per hectare	187	178	189	189	189	192	180
Kilogrammes of phosphorus per hectare	30	29	31	31	30	31	31
Kilogrammes of P_2O_5 per hectare	69	67	70	71	70	71	72
Calculated grassland yield							
Number of farms	207	201	198	209	220	218	218
Tonnes of dry matter per hectare	10.2	10.1	9.7	10.0	10.0	11.0	10.8
Kilogrammes of nitrogen per hectare	282	261	270	261	259	277	259
Kilogrammes of phosphorus per hectare	35	38	38	35	36	39	39
Kilogrammes of P_2O_5 per hectare	80	87	87	81	82	89	90

Table A4.5B Calculated crop yields (in kg of dry matter, nitrogen, phosphate and P_2O_5 per hectare) for grassland and estimated silage maize yields on farms participating in the derogation monitoring network that meet the criteria for application of the grassland yield calculation method (Aarts et al., 2008): average values for the 2006-2011 period, results for 2012, differences between 2012 results and the average values for the 2006-2011 period, and trends identified for the 2006-2012 period (also see Table A4.5A)

Description	*Average 2006-2011*	*2012*	*Difference*	*Trend*
Estimated silage maize yield				
Number of farms	156	160		
Tonnes of dry matter per hectare	15.8	16.9	+	+
Kilogrammes of nitrogen per hectare	187	180	-	≈
Kilogrammes of phosphorus per hectare	30	31	≈	+
Kilogrammes of P_2O_5 per hectare	70	72	≈	+
Calculated grassland yield				
Number of farms	209	218		
Tonnes of dry matter per hectare	10.2	10.8	+	+
Kilogrammes of nitrogen per hectare	268	259	≈	-
Kilogrammes of phosphorus per hectare	37	39	+	+
Kilogrammes of P_2O_5 per hectare	84	90	+	+

Difference: direction and significance of difference between 2012 and average for previous years.
≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2012 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.6A Nitrogen surplus on soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2012 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Number of farms	273	278	277	270	276	278	281
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	331	332	336	336	353	341	332
Outputs of milk, animals, feedstuffs, manure and other products	143	152	158	149	167	166	153
Deposition, mineralisation and nitrogen fixation	58	57	57	56	52	58	58
Gaseous emissions resulting from stabling, storage, grazing and application	52	56	57	54	54	53	50
Average surplus on soil surface balance	194	181	178	187	184	181	188
Surplus on soil surface balance (25th percentile)[1]	134	126	124	132	131	135	138
Surplus on soil surface balance (75th percentile)[2]	244	240	216	222	221	222	224

[1] Upper limit of the 25 percent of farms with the lowest surplus on the soil surface balance

[2] Lower limit of the 25 percent of farms with the highest surplus on the soil surface balanceTable

A4.6B Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2011 period, results for 2012, differences between 2012 results and the average values for the 2006-2011 period, and trends identified for the 2006-2012 period (also see Table A4.6A)

Description	*Average 2006-2011*	*2012*	*Difference*	*Trend*
Number of farms	275	281		
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	338	332	≈	≈
Outputs of milk, animals, feedstuffs, manure and other products	156	153	≈	+
Deposition, mineralisation and nitrogen fixation	56	58	+	-
Gaseous emissions resulting from stabling, storage, grazing and application	54	50	-	-
Average surplus on soil surface balance	184	188	≈	≈
Surplus on soil surface balance (25th percentile)[1]	130	138		
Surplus on soil surface balance (75th percentile)[2]	227	224		

[1] Upper limit of the 25 percent of farms with the lowest surplus on the soil surface balance

[2] Lower limit of the 25 percent of farms with the highest surplus on the soil surface balance

Difference: direction and significance of difference between 2012 and average for previous years.

≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).

Trend: direction and significance of trend in 2006-2012 period.

≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.7A Nitrogen surplus on soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2012 period

Region	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Sand Region (N = 138-145)	179	168	165	171	168	166	174
Loess Region (N = 15-19)	134	133	141	121	158	154	159
Clay Region (N = 63-69)[1]	195	178	187	206	178	172	179
Peat Region (N = 47-55)	255	237	219	233	247	241	242
All farms (N = 270-281)	194	181	178	187	184	181	188

[1] The figures presented here differ from previously published figures due to a correction to the nitrogen contents of the roughage stocks in 2007. This correction mainly affects the results for clay areas in 2007 and 2008.

Table A4.7B Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2011 period, results for 2012, differences between 2012 results and the average values for the 2006-2011 period, and trends identified for the 2006-2012 period (also see Table A4.7A)

Region	*Average 2006-2011*	*2012*	*Difference*	*Trend*
Sand Region (N = 138-145)	170	174	≈	≈
Loess Region (N = 15-19)	143	159	≈	≈
Clay Region (N = 63-69)	186	179	≈	≈
Peat Region (N = 47-55)	239	242	≈	≈
All farms (N = 270-281)	185	188	≈	≈

Difference: direction and significance of difference between 2012 and average for previous years.
≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2012 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.8A Phosphate surplus on the soil surface balance (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2012 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Number of farms	273	278	277	270	276	278	281
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	87	80	84	82	88	82	75
Outputs of milk, animals, feedstuffs, manure and other products	61	69	69	65	72	71	66
Average surplus on soil surface balance	26	12	15	17	15	11	9
Surplus on soil surface balance (25th percentile)[1]	10	-2	2	3	4	-1	-1
Surplus on soil surface balance (75th percentile)[2]	38	28	27	29	28	26	20

[1] Upper limit of the 25 percent of farms with the lowest surplus on the soil surface balance
[2] Lower limit of the 25 percent of farms with the highest surplus on the soil surface balance

Table A4.8B Phosphate surplus on the soil surface balance (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2011 period, results for 2012, differences between 2012 results and the average values for the 2006-2011 period, and trends identified for the 2006-2012 period (also see Table A4.8A)

Description	*Average 2006-2011*	*2012*	*Difference*	*Trend*
Number of farms	275	281		
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	84	75	-	-
Outputs of milk, animals, feedstuffs, manure and other products	68	66	≈	≈
Average surplus on soil surface balance	16	9	-	-
Surplus on soil surface balance (25th percentile)[1]	3	-1		
Surplus on soil surface balance (75th percentile)[2]	29	20		

[1] Upper limit of the 25 percent of farms with the lowest surplus on the soil surface balance

[2] Lower limit of the 25 percent of farms with the highest surplus on the soil surface balance

Difference: direction and significance of difference between 2012 and average for previous years.

≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).

Trend: direction and significance of trend in 2006-2012 period.

≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.9A Average nutrient concentrations (in mg/l) in water leaching from the root zone and ditch water in the 2007-2013 period

	2007	2008	2009	2010	2011	2012	2013
Water leaching from root zone in Clay Region							
Number of farms	61	63	64	64	63	59	67
Nitrate	26	16	15	19	14	11	11
Phosphorus	0.35	0.40	0.32	0.25	0.27	0.33	0.25
Nitrogen	9.1	6.2	5.5	6.3	5.2	4.7	4.5
Ditch water in Clay Region							
Number of farms	60	59	63	63	62	58	66
Nitrate	12	8.7	6.9	9.7	6.3	5.3	4.3
Phosphorus	0.32	0.35	0.35	0.22	0.27	0.25	0.26
Nitrogen	4.3	4.0	3.7	4.2	3.5	3.2	3.3
Water leaching from root zone in Sand Region							
Number	143	142	142	143	142	147	151
Nitrate	60	46	41	49	40	36	38
Phosphorus	0.07	0.07	0.07	0.09	0.11	0.10	0.10
Nitrogen	16	14	12	14	12	11	11
Ditch water in Sand Region							
Number of farms	31	33	34	34	35	35	35
Nitrate	34	33	26	31	25	19	20
Phosphorus	0.14	0.13	0.21	0.12	0.09	0.11	0.13
Nitrogen	9.4	9.5	8.2	9.2	7.7	6.6	6.9
Water leaching from root zone in Peat Region							
Number of farms	49	49	48	48	49	51	57
Nitrate	15	6.0	6.3	13	6.9	4.2	6.2
Phosphorus	0.51	0.39	0.32	0.44	0.37	0.42	0.43
Nitrogen	10.7	9.7	8.2	10.7	9.4	8.0	8.3
Ditch water in Peat Region							
Number of farms	49	48	47	47	48	50	56
Nitrate	5.9	4.2	3.5	3.7	3.7	2.8	2.5
Phosphorus	0.21	0.13	0.15	0.14	0.15	0.16	0.20
Nitrogen	3.7	4.2	4.3	4.1	4.6	4.0	4.1
Water leaching from root zone in Loess Region							
Number of farms	18	18	20	18	19	19	
Nitrate	71	52	50	50	56	54	
Phosphorus	0.02	0.03	0.02	0.03	*	0.01	
Nitrogen	18	13	12	12	14	14	

* The phosphorus measurements for this year were rejected (Hooijboer *et al.*, 2013).

Table A4.9B Average nutrient concentrations (in mg/l) in water leaching from the root zone and ditch water: average values for the 2007-2012 period, differences between 2013 results and the average values for the 2007-2012 period, and trends identified for the 2007-2013 period

	Average 2007-2012	*2013*	*Difference*	*Trend*
	Water leaching from root zone in Clay Region			
Nitrate	17	11	-	-
Phosphorus	0.32	0.25	≈	-
Nitrogen (N)	6.2	4.5	-	-
	Ditch water in Clay Region			
Nitrate	8.2	4.3	-	-
Phosphorus	0.29	0.26	≈	≈
Nitrogen (N)	3.8	3.3	≈	-
	Water leaching from root zone in Sand Region			
Nitrate	45	38	-	-
Phosphorus	0.08	0.10	≈	+
Nitrogen (N)	13	11	-	-
	Ditch water in Sand Region			
Nitrate	28	20	-	-
Phosphorus	0.13	0.13	≈	≈
Nitrogen (N)	8.4	6.9	-	-
	Water leaching from root zone in Peat Region			
Nitrate	8.6	6.2	≈	-
Phosphorus	0.41	0.43	≈	≈
Nitrogen (N)	9.5	8.3	≈	-
	Ditch water in Peat Region			
Nitrate	4.0	2.5	-	-
Phosphorus	0.16	0.20	≈	≈
Nitrogen (N)	4.2	4.1	≈	≈
	Water leaching from root zone in Loess Region[1]			
	Average 2007-2011	2012	Difference	Trend
Nitrate	56	54	≈	-
Phosphorus	<DT	<DT	≈	≈
Nitrogen (N)	13	14	≈	≈

Difference: direction and significance of difference between 2013 and average for previous years.
≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2007-2013 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).
[1] The difference was determined based on a comparison of the data for 2012 with the data for the 2007-2011 period. The data for 2013 are not yet available.
[2] Average phosphorus concentrations below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.

References

- Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2008). Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmaïs op melkveebedrijven. Wageningen, Plant Research International, Report No. 208.

Appendix 5 Fertiliser data reported by Netherlands Enterprise Agency

A5.1 Introduction

During the 2006-2009 period, the Netherlands Enterprise Agency (*Rijksdienst voor Ondernemend Nederland* or RVO.nl, formerly the National Service for the Implementation of Regulations) reported on fertiliser use based on its own data (see, for instance, National Service for the Implementation of Regulations and Netherlands Food and Consumer Product Safety Authority, 2011). All farmers are required to supply these data. In the past, the fertiliser use calculated by RVO.nl sometimes deviated from the fertiliser use calculated on the basis of data supplied by farms participating in the derogation monitoring network ('DMN farms') of the Minerals Policy Monitoring Programme (LMM). Such differences were especially apparent in the reporting year 2009. In the reporting year 2009, the use of nitrogen in livestock manure calculated by RVO.nl was 42 kg per hectare (20%) lower than the LMM data, while the use of phosphate in livestock manure was 19 kg per hectare (25%) lower than the LMM data. The Agricultural Economics Research Institute (LEI) was therefore asked to analyse these differences in detail, going back to reporting year 2010. This Appendix compares the calculated fertiliser use data in this report with the fertiliser use calculated by RVO.nl, and provides an explanation of any differences that were found.

The LMM calculations are aimed at calculating the fertilisation rates as accurately as possible, using as much farm-specific information as possible. The fertiliser use calculations performed by RVO.nl serve a different purpose than the LMM calculations (Table A5.1), as the former are chiefly aimed at discovering possible offenders. There are also differences in the population. The LMM population is a sample of the Agricultural Census data that excludes very small farms. The RVO.nl data concern all farms included in the Agricultural Census that have applied for derogation.

Table A5.1 Fertiliser use in kg per hectare on farms to which derogation has been granted according to RVO.nl data, fertiliser use in kg per hectare on farms according to LMM derogation monitoring results, and differences between these source data in 2012 for both nitrogen and phosphate

			Difference between LMM and RVO.nl data	
Item	*LMM*	*RVO.nl*	*In kg/ha*	*In %*
Nitrogen in livestock manure	239	207	32	16%
Nitrogen in inorganic fertilisers	126	108	18	16%
Nitrogen in other organic fertilisers	0	4	-3	-95%
Total nitrogen	365	319	47	15%
Phosphate in livestock manure	84	74	10	14%
Phosphate in inorganic fertilisers	3	2	1	67%
Phosphate in other organic fertilisers	0	1	-1	-80%
Total phosphate	87	77	10	13%

A5.2 Summary and analysis of differences

A5.2.1 Nitrogen and phosphate in livestock manure

The calculated quantity of nitrogen in livestock manure is 32 kg per hectare higher according to LMM data than according to RVO.nl data. This difference amounts to 10 kg per hectare for phosphate in livestock manure.

Table A5.2 Analysis of differences in the use of livestock manure on farms to which derogation has been granted, according to RVO.nl data and according to LMM derogation monitoring results in 2012 for nitrogen

	Nitrogen	
Item	*kg N/ha*	*Percentage*
Reported LMM value (A)	239	
Reported RVO.nl value (B)	207	
Reported RVO.nl value ≥ 10 hectares, ≥ 25,000 SO units and within LMM confidence intervals (C)	229	
Difference observed in similar population (A – C)	10	
Caused by		
a. RVO.nl population ≥ 10 hectares, ≥ 25,000 SO units and within LMM confidence intervals, versus LMM derogation farms with RVO.nl data	4.0	42%
b. Stocks	-1.2	-13%
c. Inputs and outputs	0.1	1%
d. Use of BEX* method in LMM programme	-7.3	-77%
e. Standard-based excretion by dairy cows	1.1	11%
f. Standard-based excretion by other cattle	9.7	101%
g. Standard-based excretion by other grazing animals	1.1	11%
h. Standard-based excretion by intensive livestock	2.4	25%

Source: RVO.nl and FADN data processed by LEI
* The abbreviation BEX stands for *Bedrijfsspecifieke Excretie* (Farm-Specific Excretion) (National Service for the Implementation of Regulations, 2010).

Table A5.2 summarises the reasons for these differences. Approx. two-thirds of the difference of 32 kg per hectare found in Table A5.1 (229 – 207 = 22 kg) is due to differences in populations. Farms smaller than 10 hectares and smaller than 25,000 SO units are excluded from the LMM programme, but not from the RVO.nl data. In addition, the LMM programme uses confidence intervals (see Appendix 2, Table A2.1), so that farms with improbably high or low fertilisation rates are excluded from the data set. Fertiliser use on these excluded farms is substantially lower.
The remaining difference of 10 kg may be attributed to the following factors (expressed as percentages of the 10 kg difference in Table A5.2, and listed as items a through h).

a. The 261 LMM observations may be considered as a sample from the much larger RVO.nl population of farms with a size of 10 hectares or more, an economic size of 25,000 SO units or more, and falling within the LMM confidence intervals (i.e. the sample population). If the fertiliser use on these 261 farms is calculated based on RVO.nl data, the result deviates by 4 kg from the results for this much larger RVO.nl population. This may be considered a sampling difference and explains more than 40 percent of the remaining difference of 10 kg.

b. and c. In addition, the stocks, inputs and outputs registered in the LMM programme sometimes differ from the RVO.nl data. FADN participants are requested to report the actual situation, which may differ from the RVO.nl data. The net effect of these discrepancies in 2012 was that the calculated LMM fertiliser quantities were approx. 1 kg per hectare lower than the RVO.nl quantities. This amounts to a difference of 13% compared to the A – C difference in Table A5.2. In 2009 the RVO.nl quantities were higher than the LMM quantities. The net difference in 2010 was in the same direction as in 2011 and 2012, but exceeded the difference in 2011 and 2012 by a factor of five.
d. The remaining difference (7 kg per hectare; items d through h) is accounted for by differences in the method used to calculate excretion quantities. The BEX method is used by approx. two-fifths of the farms participating in the LMM programme. As a result, the use of nitrogen in livestock manure according to the LMM data is more than 7 kg per hectare less than according to the RVO.nl data. The BEX method is applied in the LMM programme for all farms that report using the BEX method, provided that sufficient reliable data are available.
e. The standard-based excretion in the LMM programme is determined with greater accuracy than in the RVO.nl data, for a number of reasons. RVO.nl is not always able to calculate excretion by dairy cows because it lacks data on milk supplies or urea levels.
f. Furthermore, the LMM programme takes the stable system into account when determining the standard quantities. The stable system is not registered in the RVO.nl data, so the lower standard quantities for solid manure are selected in the case of young livestock.
g. In addition, RVO.nl does not classify excretion by hobby animals as ‘Excretion’, but as ‘Other organic fertilisers’.
h. In addition, the excretion by intensive livestock is calculated differently, e.g. due to differences in the initial and closing stocks.

Nitrogen in inorganic fertilisers and other fertilisers
The differences in the use of nitrogen in inorganic fertilisers and other fertilisers are minor compared to the differences in the use of nitrogen in livestock manure. They can largely be explained by the following factors:
- The farms excluded due to sampling limitations and confidence intervals use less fertilisers.
- RVO.nl classifies excretion by hobby animals as ‘Other organic fertilisers’.

Phosphate
The nitrogen-phosphate ratio in cattle manure is reasonably stable. This also applies to other organic fertilisers. The differences in Table A5.1 for phosphate in livestock manure and other organic fertilisers are caused by the same factors as for nitrogen. In the case of phosphate in inorganic fertilisers, the difference in kilogrammes stated in Table A5.1 is small.

The differences do not give cause to adjust the LMM calculation method, either for nitrogen or for phosphate.

A5.3 Data sources

We used the following data sources to compare RVO.nl and LMM figures for 2012:

- Farm Accountancy Data Network (FADN) of the Agricultural Economics Research Institute (LEI): this concerns the 298 farms that qualified for derogation monitoring (DM) in 2012. We mainly analysed the fertilisation data, but also used other FADN data about these farms. These farms are all participants in the LMM programme and will therefore be referred to below as 'LMM farms', and the data provided as 'LMM data'.
- Data from the Netherlands Enterprise Agency (RVO.nl): this concerns 23,504 registration numbers (BRS numbers) of farms that applied for derogation in 2012. Thirteen BRS numbers have been added which were included in the 298 LMM farms, but not in the 23,504 BRS numbers.
- Data from the 2012 Agricultural Census concerning the 23,504 BRS numbers. In the case of 2,098 BRS numbers, no number could be found in the 2012 Agricultural Census, leaving 21,406 BRS numbers with Agricultural Census data.

On LMM farms, fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals. This applies to the separate quantities of nitrogen and phosphate, as well as the total quantities of fertilisers applied (i.e. inorganic fertilisers, livestock manure, and other organic fertilisers). The relevant table may be found in Appendix 2 (Table A2.1).

Furthermore, LMM farms with anaerobic digestion installations are also excluded, as well as farms that did not actually make use of the exemption in the year concerned (this applied to three farms in 2012). Consequently, the number of LMM farms used for derogation monitoring purposes in 2012 decreased from 298 to 281. The fertiliser use of these 281 LMM farms is also calculated based on their RVO.nl data. For this purpose, 290 BRS numbers were linked to the 281 LMM farms because some LMM farms have two BRS numbers. In those cases, the data belonging to the two BRS numbers were combined. Twenty LMM farms with 21 BRS numbers turned out to fall outside the scope of Appendix 2 based on their RVO.nl data, among other things because their milk production and urea level data were missing from the RVO.nl data. Eventually, the comparison was made for 261 LMM farms with 269 BRS numbers.

A5.4 Detailed results

A5.4.1 Nitrogen in livestock manure

Differences in population

Table A5.3 shows the production, inputs, outputs, initial stocks and closing stocks of livestock manure expressed in kg of nitrogen per hectare for the 23,504 RVO.nl observations, excluding farms without cultivated land. Of these 21,584 RVO.nl observations, 1,512 observations fell outside the confidence intervals. Approximately 40 percent of these 1,512 observations concerned farms smaller than 10 hectares. The RVO.nl data set also included 2,917 farms smaller than 10 hectares or smaller than 25,000 SO units which did fall within the confidence intervals.

Table A5.3 Excretion (= production), inputs, outputs, stocks and use of livestock manure in kg of nitrogen per farm and per hectare, according to RVO.nl data for BRS numbers in 2012 that applied for derogation in 2012

	No cultivated land	*Cultivated land*			
		Total	*Outside confidence intervals*	*< 10 ha or < 25,000 SO units*	*≥ 10 ha and ≥ 25,000 SO units*
Number of farms	1,920	21,584	1,512	2,917	17,155
Acreage of cultivated land (hectares)	0	39	27	10	44
Use of nitrogen in livestock manure (kg)		207	29	165	229
Quantity of nitrogen in initial stocks (kg)		97	196	57	95
Quantity of nitrogen in closing stocks (kg)		111	379	53	98
Initial stocks – closing stocks (kg of nitrogen)		-15	-183	5	-3
Inputs – outputs (kg of nitrogen)		-20	-175	39	-17
Nitrogen excretion (= nitrogen production) (kg)		242	387	121	249

Source: Processed RVO.nl data

Use per hectare was determined by calculating the use per hectare for each farm, and then averaging the results. Farms without cultivated land were excluded, to avoid dividing by zero. Table A5.3 shows that the BRS numbers with 10 or more hectares of cultivated land and an economic size of 25,000 or more SO units used more nitrogen in livestock manure per hectare than BRS numbers with less cultivated land or an economic size of less than 25,000 SO units. The main reason for this was that the quantity of nitrogen excreted per hectare was more than twice as high. As noted before, the LMM data are limited to farms with at least 10 hectares of cultivated land and an economic size of at least 25,000 SO units. Therefore, only the 17,155 RVO.nl observations with at least 10 hectares of cultivated land and an economic size of at least 25,000 SO units (the far right column in Table A5.3) were taken into account in the comparison with the LMM results in Table A5.4. Of these 17,155 RVO.nl observations, 269 observations (LMM in accordance with RVO.nl) were linked to 261 LMM observations (see the end of section A5.3).

The comparison in Table A5.4 concerns surface areas, use of nitrogen in livestock manure, and stock changes of nitrogen in livestock manure. Data on excretions of nitrogen in livestock manure are also presented and classified according to the different groups of animals.

Table A5.4 shows that the entire group of derogation farms in the 2012 RVO.nl data set with at least 10 hectares of cultivated land, at least 25,000 SO units and falling within the LMM confidence intervals, had a smaller average surface area (44 hectares compared to 57 hectares). The difference in acreage between the LMM results and the LMM results calculated using RVO.nl data amounted to 0.23 hectares. This does not affect the differences.

Table A5.4 Use, inputs minus outputs, stock differences and excretion (= production) of livestock manure in 2012, classified according to type of animal, expressed in kg of nitrogen per hectare, according to RVO.nl and LMM data for farms participating in the LMM derogation monitoring network and for RVO.nl derogation farms with at least 10 hectares of cultivated land, an economic size of at least 25,000 SO units, and with fertiliser use falling within the LMM confidence intervals

	RVO.nl ≥ 10 ha, ≥ 25,000 SO units	*LMM*	*LMM in accordance with RVO.nl*	*LMM - LMM in accordance with RVO.nl*
Number of farms	17,155	261	261	
Acreage of cultivated land (hectares)	44	57	56	0
No. of Phosphate LSUs per hectare	2.3	2.3	2.4	0.0
Results per hectare				
Use of nitrogen in livestock manure (kg)	229	239	233	6
Use of nitrogen in livestock manure according to BEX method → standard-based (kg)	229	246	233	13
Initial stocks – closing stocks (kg of nitrogen)	-3.1	-4.6	-3.4	-1
Inputs – outputs (kg of nitrogen)	-17	-16	-16	0
Nitrogen excretion (= nitrogen production) (kg)	249	259	252	7
Nitrogen excretion (= nitrogen production) (kg) according to BEX method → standard-based	249	267	252	14
- Of which dairy cows	172	191	190	1
- Of which other cattle, excluding white veal calves	65	68	59	10
- Ditto after correction for type of fertiliser	*74*	*68*	*67*	*2*
- Of which sheep, goats and horses	4.0	2.4	1.3	1.1
- Ditto after adding excretion by hobby animals	*3.4*	*2.4*	*2.0*	*0.3*
- Of which intensive livestock, including white veal calves	7.7	4.8	2.5	2.4

Source: RVO.nl and FADN data processed by LEI

This RVO.nl population was also characterised by slightly less intensive farming (2.32 Phosphate LSUs per hectare compared to 2.36 Phosphate LSUs per hectare) than the LMM derogation farms according to the RVO.nl data. According to the LMM calculations, the use of nitrogen in livestock manure on the 261 LMM derogation farms amounted to almost 246 kg per hectare (calculations for all LMM farms performed based on standard quantities), whereas the figure of 239 kg for 261 LMM farms is stated in Table A5.1.

Differences in calculated use
The excretion quantities stated in Table A5.4 have been rendered comparable based on standard quantities, as excretion quantities are arrived at by means of different, incompatible methods in the LMM and RVO.nl systems. The calculations for approx. two-fifths of the LMM farms represented in Table A5.1 were performed in accordance with the Farm-Specific Excretion (BEX) method (refer to the guidance document on farm-specific excretion by dairy cattle).

According to the LMM calculations, the use of nitrogen in livestock manure on LMM derogation farms was 10 kg per hectare (239 kg compared to 229 kg) higher than calculated on the basis of RVO.nl data for the RVO.nl population within the LMM scope. This difference increases to 17 kg (246 – 229) when we perform the LMM calculations using standard-based excretion quantities (as with the RVO.nl data). If the use of nitrogen in livestock manure on the 261 LMM derogation farms is calculated based on the relevant RVO.nl data (item 'LMM in accordance with RVO.nl' in Table A5.4), the entire group of RVO.nl derogation farms also has slightly lower usage (229 kg versus 233 kg) than the LMM derogation farms.
The differences in the quantities of nitrogen per hectare between the LMM calculations and the RVO.nl calculations (item 'LMM – LMM in accordance with RVO.nl' in Table A5.4) mainly concern the excretion quantities (14 kg). Because the stock increases were higher according to the LMM calculations than according to the RVO.nl calculations (the net output is the same), the difference in the use of livestock manure was smaller (13 kg).

The 14 kg difference in excretion quantities concerns the following groups of animals:
- Dairy cows (1 kg): The LMM figures included all the milk produced, i.e. not only supplies but also waste milk and milk fed to young livestock and pigs. This resulted in a milk production per cow that was 100 kg higher than if the calculations had been performed based on RVO.nl data. This corresponds with a difference of 1.2 kg in nitrogen excretion per hectare.
- Other cattle, excluding white veal calves (10 kg): For this group of animals, RVO.nl apparently used the standard excretion quantities for solid manure, which are lower than those for liquid manure. According to the 2008 Agricultural Census (the most recent Agricultural Census which requested information on solid cattle manure versus liquid cattle manure), approx. 55 percent of young livestock up to 1 year old, 95 percent of young female livestock older than 1 year and intended for breeding, and 70 percent of beef cattle and grazing and suckler cows, are accommodated in stables with liquid manure. By taking into account the differences in excretion quantities between solid and liquid manure systems in respect of the percentages for these specific groups of animals, the excretion quantity in the calculations based on RVO.nl data increases by 7.8 kg of nitrogen per hectare. This means that little difference remains between the LMM and RVO.nl calculations.

- Sheep, goats and horses: Two-thirds (0.7 kg) of the 1.1 kg difference between the LMM calculations and the RVO.nl calculations is caused by the fact that RVO.nl regards groups of animals with less than 350 kg of nitrogen excretion as 'hobby animals'. It classifies excretion by these animals under 'Other organic fertilisers'. These hobby animals are mainly sheep and horses.
- Intensive livestock (2.4 kg): The LMM and RVO.nl systems do not use exactly the same basic data (e.g. stocks) to determine the excretions of intensive livestock.

A5.4.2 Nitrogen in inorganic fertilisers and other organic fertilisers

Table A5.5 specifies the use per hectare of nitrogen in inorganic fertilisers and other organic fertilisers, calculated for all 23,504 BRS numbers in the RVO.nl data set excluding the 1920 BRS numbers without cultivated land (RVO.nl > 0 hectares), as well as for the 17,155 BRS numbers with at least 10 hectares of cultivated land, an economic size of at least 25,000 SO units, and with fertiliser use falling within the LMM confidence intervals (RVO.nl ≥ 10 hectares, ≥ 25,000 SO units).

Table A5.5 Use in 2012 of nitrogen in inorganic fertilisers and other organic fertilisers, expressed in kg of nitrogen per hectare according to RVO.nl data and LMM data for farms in the LMM derogation monitoring network, for RVO.nl derogation farms with cultivated land and for RVO.nl derogation farms with at least 10 hectares of cultivated land, an economic size of at least 25,000 SO units, and with fertiliser use falling within the LMM confidence intervals

	RVO.nl > 0 ha	*RVO.nl ≥ 10 ha, ≥ 25,000 SO units*	*LMM*	*LMM in accordance with RVO.nl*	*LMM - LMM in accordance with RVO.nl*
Number of farms	21,584	17,155	261	261	
Acreage of cultivated land (hectares)	39	44	57	56	0
Results per hectare					
Inorganic fertilisers	108	118	126	118	8
Other organic fertilisers	3.6	1.5	0.2	0.8	-0.6
Ditto after excluding excretion by hobby animals	0.2	0.4	0.2	0.0	0.1

Source: RVO.nl and FADN data processed by LEI

The RVO.nl results per farm for the 21,584 BRS numbers with cultivated land differed from the RVO.nl results for the 17,155 BRS numbers with at least 10 hectares of cultivated land, an economic size of at least 25,000 SO units, and fertiliser use falling within the LMM confidence intervals. For the group as a whole, the use of nitrogen in inorganic fertilisers was lower, but the use of nitrogen in other organic fertilisers was higher. The main reason for this is the inclusion of BRS numbers with fertiliser use that fell outside the LMM confidence intervals.

In respect of the much smaller group of LMM derogation farms for which RVO.nl data were also available, the use of nitrogen in inorganic fertilisers calculated according to LMM data was nearly 10 percent higher than if the calculations had been performed using RVO.nl data. There was virtually no difference in the use of nitrogen in other organic fertilisers, after the RVO.nl data had been corrected for nitrogen excretion by hobby animals.

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A.E.J. Hooijboer et al.

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