Agricultural practices and water quality *on farms* registered for derogation in 2019

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Synopsis

Agricultural practices and water quality on farms registered for derogation in 2019

Dutch grassland farms that meet certain conditions may use more animal manure, which contains nitrogen, than the general limit as prescribed by the European Nitrates Directive. This partial exemption is referred to as 'derogation'. The National Institute for Public Health and the Environment (RIVM) and Wageningen Economic Research monitor the effects of this derogation on the water quality on 300 farms in the derogation monitoring network. This study shows the results for 2019 and the development from 2006 onwards.

This study concludes that derogation has no negative effects on water quality. However the droughts have had adverse consequences for the water quality in 2019 and 2020. Drought led, amongst other things, to decreased crop growth, resulting in reduced nitrogen uptake. As a consequence, more nitrogen was left in the soil and ended up in the groundwater.

Management
On average, derogation farms have used 230 kilograms of nitrogen from animal manure per hectare in 2019. The permissible amount of nitrogen from animal manure varies from 230 to 250 kilograms per hectare, depending on the soil type and region.

In recent years, improvements in management have resulted in more efficient use of nitrogen for crop production; the nitrogen surplus on the soil surface balance has dropped in the period from 2006 until 2017. This means that in those years less nitrogen, in the form of nitrate, was available to leach to lower soil depths and eventually into the groundwater. In 2019 the soil nitrogen surplus was, after an increase in 2018 because of the drought, the lowest of all the studied years.

Groundwater quality
The average nitrate concentration on derogations farms increased in 2019 and 2020. This is presumably because of the droughts. In the south and east of the Sand region the concentrations rose above the EU-standard of 50 milligram per litre (63 milligram per litre). If the entire investigated period (2006-2020) is taken into account, the concentrations in the entire Sand region still show a downward tendency. In the Loess region the concentration still exceeded the EU-standard, although it is still lower than in 2018 (59 milligram per litre in 2019 compared to 65 milligram per litre in 2018). Concentrations decreased in the Clay region and the Peat region. The nitrate concentration in the Clay region shows an upward tendency, but was consistently under the standard.

The monitoring was commissioned by the Ministry of Agriculture, Nature & Food Quality.

Keywords: derogation, agricultural practice, manure, Nitrates Directive, water quality.

Publiekssamenvatting

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie in 2019

In Nederland mogen bepaalde agrarische bedrijven meer dierlijke mest, waar stikstof in zit, op hun land gebruiken dan de algemene norm van de Europese Nitraatrichtlijn voorschrijft. Zij moeten hiervoor wel aan specifieke voorwaarden voldoen. Deze verruiming heet derogatie. Het RIVM en Wageningen Economic Research meten elk jaar de gevolgen van de derogatie voor de waterkwaliteit op driehonderd bedrijven. Ook worden de ontwikkelingen sinds 2006 geanalyseerd, het jaar waarin de derogatie inging.

Uit de analyse blijkt dat de derogatie geen negatieve effecten heeft op de waterkwaliteit vanaf 2006. Wel heeft de droogte er in 2019 en 2020 negatieve effecten op gehad. Door de droogte groeiden onder andere de gewassen minder goed, waardoor zij minder stikstof opnamen. Hierdoor bleef er meer stikstof in de bodem achter en kwam er meer in het grondwater terecht.

Bedrijfsvoering
In 2019 hebben derogatiebedrijven gemiddeld 230 kilogram stikstof uit dierlijke mest per hectare gebruikt. Dit wordt in kilogrammen stikstof aangegeven omdat het per diersoort verschilt hoeveel stikstof er in mest zit. Een derogatiebedrijf mag 230 of 250 kilogram stikstof per hectare uit graasdiermest gebruiken, afhankelijk van de bodemsoort en regio.

Door verbeteringen in de bedrijfsvoering wordt dierlijke mest efficiënter gebruikt om gewassen te laten groeien. Het ‘stikstofbodemoverschot’ is daardoor van 2006 tot en met 2017 gedaald. Dit betekent dat er in deze jaren minder stikstof beschikbaar is om als nitraat met regenwater weg te zakken naar diepere lagen in de bodem en uiteindelijk het grondwater. Na een stijging in 2018 door de droogte, was in 2019 het stikstofbodemoverschot het laagste van alle onderzochte jaren.

Grondwaterkwaliteit
De gemiddelde nitraatconcentratie op derogatiebedrijven nam in 2019 en 2020 toe. Dit komt waarschijnlijk door de droogte. In het zuiden en oosten van de Zandregio steeg de concentratie in 2020 tot boven de EU-norm van 50 milligram per liter (63 milligram per liter). Als de hele onderzochte periode (2006-2020) wordt bekeken, is de concentratie in de hele Zandregio wel gedaald. In de Lössregio bleef de concentratie boven de norm, al is deze lager dan in 2018 (59 milligram per liter in 2019 versus 65 milligram per liter in 2018). In de Klei- en Veenregio daalde de nitraatconcentratie in 2020. In de Kleiregio is in de hele onderzochte periode de nitraatconcentratie gestegen, maar blijft deze steeds onder de norm.

De monitoring wordt uitgevoerd in opdracht van het ministerie van Landbouw, Natuur en Voedselkwaliteit (LNV).

Kernwoorden: derogatie, landbouwpraktijk, mest, Nitraatrichtlijn, waterkwaliteit

Foreword

This report provides an overview of agricultural practices and water quality in 2019 on the farms that registered for derogation in the derogation monitoring network. The agricultural practice data include data on fertiliser usage and actual nutrient surpluses. They also include the provisional data for the water quality in 2020.

This report was commissioned by the Dutch Ministry of Agriculture, Nature & Food Quality and was prepared by the National Institute for Public Health and the Environment (RIVM) in collaboration with Wageningen Economic Research. Wageningen Economic Research 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 derogation monitoring network was created in order to meet the conditions imposed by the European Commission when it granted a derogation to the Netherlands, permitting grassland farms to apply more nitrogen in the form of grazing livestock manure than the generally applicable standard of 170 kg of nitrogen per hectare. The purpose of the derogation monitoring network is to monitor the effects of this derogation on agricultural practices and water quality. 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.

The authors would like to thank Gerard Velthof and Hein ten Berge, on behalf of the of the Committee of Experts on the Fertilisers Act (Commissie Deskundigen Meststoffenwet: CDM) for their comments on a previous draft of this report. We would also like to thank all our colleagues at Wageningen Economic Research and RIVM who, each in their own way, have contributed to the realisation of this report.

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Contents

Summary

Introduction
The EU Nitrates Directive obligates Member States to limit the use of nitrogen in livestock manure to a maximum of 170 kg per hectare per year in nitrate-sensitive areas. The Netherlands has designated the entire country as being nitrate-sensitive but has received permission from the European Commission for certain farms to apply larger amounts of livestock manure, referred to as derogation. The derogation, as applicable over the period from 2018 up to and including 2019, has been granted to farms cultivating at least 80% of their total area as grassland. Farms registered for derogation in the provinces of Overijssel, Gelderland, Utrecht, North Brabant and Limburg are permitted to apply up to 230 kg of nitrogen per hectare in the form of grazing livestock manure on sandy and loessial soils. Farms registered for derogation on other soils and on sandy soils in other provinces may apply up to 250 kg of nitrogen per hectare in the form of grazing livestock manure. The conditions attached to this derogation 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. This report describes the organisation of the monitoring network and the monitoring results for 2019.

Derogation monitoring network
The derogation monitoring network was set up by expanding the Minerals Policy Monitoring Programme (of RIVM and Wageningen Economic Research). Three hundred farms that applied for derogation were distributed as evenly as possible, via a stratified random sampling method, according to soil type region (Sand Region, Loess Region, Clay Region and Peat Region), farm type (dairy farms and other grassland farms), and economic size. The agricultural practices were successfully determined for 297 of these 300 farms from the monitoring programme, and 295 actually made use of the derogation in 2019. In addition to data on agricultural practices and water quality in 2019, this report also presents data on water quality in 2020, as this information relates to agricultural practices in 2019.

Agricultural practices in 2019 on derogation farms
In 2019, the farms in the derogation monitoring network applied an average of 230 kg of nitrogen from livestock manure per hectare of cultivated land. Factoring in the statutory availability coefficients, the average quantity of plant-available nitrogen from livestock manure per hectare amounted to 111 kg of nitrogen. In addition, an average of 126 kg of nitrogen per hectare was applied in the form of inorganic fertilisers. The total amount of plant-available nitrogen applied was 236 kg per hectare.
The total amount of phosphate applied in the form of livestock manure and other organic fertilisers was 73 kg per hectare. The application of phosphate-containing fertilisers on derogation farms has not been permitted since 2014.

The average nitrogen surplus on the soil surface balance in 2019 was calculated at 156 kg per hectare. The Peat Region had the highest nitrogen surplus (204 kg/ha), primarily due to the net nitrogen mineralisation in the soil, which is included in the surplus for peat soils. On average, the phosphate surplus on the soil surface balance was 4 kg/ha.

Agricultural practices during the 2006-2019 period
After the record drought in 2018, which resulted in reduced crop yields and higher surpluses on the soil surface balance, the crop yields rebounded in 2019. However, the yields of grass in particular were still lower than the average yields in previous years, in part due to regional droughts in 2019. The nitrogen soil surpluses also decreased due to the lower input of nitrogen via, amongst other things, organic fertilisers and feed.

Between 2006 and 2019, the quantity of milk produced per farm increased by an average of 4% per year. The area of cultivated land per farm has increased since 2006 and was 54 ha in 2019. The milk production per hectare increased over the period from 2006 up to and including 2016 but has stabilised since then.

Over time, the phosphate production by intensive livestock (including veal calves and pigs) in livestock units (LSU) per hectare decreased due to a decrease in the number of intensive livestock farms. However, due to an increase in the number of milk cows per farm, the average phosphate production remained the same.

The average proportion of grassland on derogation farms has increased to almost 88% since 2014. Between 2006 and 2015, the number of farms with grazing decreased from 89% to 76%. In recent years, the proportion of farms with grazing participating in the derogation monitoring network has gone back up again, reaching 88% in 2019.

Since 2006, the average quantity of nitrogen applied in the form of livestock manure has ranged from 230 kg to 246 kg of nitrogen per hectare. In 2019, 230 kg of nitrogen from animal manure was applied per hectare, which was less than during the previous six years.

The total application of plant-available nitrogen per hectare was lower in 2019 than in the previous five years. The application of plant-available nitrogen via livestock manure as well as via inorganic fertilisers was lower in 2019 than the average figure for previous years.

The application standard for phosphate decreased by more than 20% between 2006 and 2019, from 108 to 84 kg/ha of phosphate. This accompanied an almost equally large decrease in the application of phosphate, from an average of 100 to 73 kg/ha of phosphate in 2019. Since 2014, the use of phosphate from inorganic fertilisers has no longer been permitted on derogation farms.

After the reduced yields of grass in 2018 due to the drought, the yields of grass rebounded in 2019. The average yield of grass was 9,700 kg/ha, which was still lower than the average yield realised from 2006 up to and including 2018. The yield of silage maze increased slightly, and was at the same level as the long-term average. The average nitrogen and phosphorus yields for both crops also rebounded in 2019 in comparison to 2018.

In 2019, the average nitrogen surplus on the soil surface balance was 156 kg/ha, which was the lowest figure calculated during the entire series of measurements since 2006. The nitrogen soil surplus was on average 24 kg/ha of nitrogen lower than the average figure for the 2006-2018 period; the phosphate surplus was 7 kg/ha. The decrease in the nitrogen soil surplus in 2019 was primarily due to the decreased input of nitrogen via, amongst other things, organic fertilisers and feed. The nitrogen soil surplus as well as the phosphate surplus show a decreasing trend over the entire measurement period.

Quality of water leaching from the root zone in 2019
In 2019, the nitrate concentrations in the water leaching from the root zone in all regions, with the exception of the Loess Region, were, on average, lower than the nitrate standard of 50 mg/l. The average nitrate concentration in the Loess Region was 59 mg/l.

There is a clear difference between the nitrate concentration in the water leaching from the root zone in the Sand Region with an application standard of 230 kg/ha of nitrogen and the Sand Region with an application standard of 250 kg/ha, namely 47 mg/l and 23 mg/l, respectively. This can be explained by the higher proportion of drier soils in the southern provinces (Sand-230) as well as the higher proportion of wetland soils in the northern provinces (Sand-250). In drier soil, nitrate is broken down less via denitrification, which makes such soils more sensitive to nitrate leaching from the root zone. In wetlands, nitrate is actually broken down more quickly. The Loess Region is also characterised by drier soils.

The nitrate concentration in the water leaching from the root zone in the Clay Region increased in 2019 by more than half in comparison to 2018, namely to a value of 44 mg/l. The drought of 2018 probably plays a major role in this increase.
The lowest average nitrate concentration in the water leaching from the root zone was measured in the Peat Region (16 mg/l). This is due to the higher rate of nitrate decomposition as a result of denitrification in this region due to the presence of soils that are wetter and richer in organic content.

Although the average nitrate concentration in most of the regions was below the EU standard of 50 mg/l, this standard was regularly exceeded on individual farms. In Sand-230, 39% of the farms sampled had nitrate concentrations in the water leaching from the root zone that were higher than 50 mg/l; in the Loess Region this figure was 60%, and in the Clay Region it was true of 38 percent of the farms. In the Peat Region and in Sand-250, 12% and 9% of the farms, respectively, had nitrate concentrations that exceeded the EU standard.

The highest phosphorus concentration in water leaching from the root zone was measured in the Peat Region (0.37 mg/l), followed by the Clay Region (0.33 mg/l) and Sand-250 (0.22 mg/l). The average phosphorus concentration in Sand-230 was 0.1 mg/l, and in the Loess Region it was below the detection level (0.05 mg/l. These phosphorus concentrations are below the national threshold value (2 mg/l) for phosphorus in groundwater.

Water leaching from the root zone from 2007 up to and including 2020

Up to and including 2017, there was a clear downward trend in the nitrate concentrations in the water leaching from the root zone in all regions, with the exception of the Peat Region where the average nitrate concentration has always been low.
Due to the droughts in 2017 and 2018, the concentrations in all regions have increased in recent years. In 2020, the nitrate concentrations decreased again in the Clay and Peat regions. However, the nitrate concentrations in the Sand regions increased further, possibly due in part to the local drought in 2019. The nitrate concentration in the Loess Region decreased slightly in 2019 after a strong increase in 2018.

Drought leads to increased nitrate concentrations due to reduced denitrification and evaporation of soil moisture. In addition, drought can also lead to lower crop yields, which in turn result in increased nitrogen soil surpluses. This was the case in particular in 2018 but played less of a role in 2019.

The average nitrate concentration in 2020 in Sand-250 was 26 mg/l. The concentration in Sand-230 increased further to 64 mg/l and the average value exceeded the standard of 50 mg/l. Nevertheless, a statistically significant downward trend can still be seen since 2006 in both Sand regions. In 2020, the concentration in the Clay Region decreased slightly to 37 mg/l, but this is still more than twice as high as the average value recorded over the entire measurement period and now shows an increasing trend. With a concentration of 12 mg/l, the Peat Region, where low nitrate concentrations have been measured during the entire measurement period, does not differ from previous years.

Phosphorus concentrations in water leaching from the root zone in the Clay and Peat regions show a decreasing trend, whereas these concentrations remain stable in the other regions.

Relationship between agricultural practices and water quality

Between 2006 and 2019, the average nitrogen soil surpluses over all the regions showed a decreasing trend. The nitrate concentrations in the water leaching from the root zone also decreased in most of the regions up to and including 2017. This is in line with the expectation that decreasing soil surpluses lead to decreasing nitrate concentrations.

The increased nitrogen soil surpluses that occurred in 2018 as a result of disappointing crop production due to the drought were followed in 2019 by increases of the nitrate concentrations in the water leaching from the root zone. Even though nitrogen soil surpluses decreased again in 2019, the nitrate concentrations in 2020 were still relatively high, particularly in Sand-230 and the Clay Region. This is probably due to the fact that the increased nitrogen soil surpluses in 2018 continue to have an effect for more than one year.

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 per hectare per year (EU, 1991) in nitrate-sensitive areas. A Member State can request the European Commission for exemption from this obligation under certain conditions (hereinafter 'derogation'). In December 2005, the European Commission issued the Netherlands with a derogation decision for the 2006-2009 period (EU, 2005). In February 2010, the derogation decision was extended until the end of December 2013 (EU, 2010). During this period, grassland farms cultivating at least 70% of their total area as grassland were allowed to apply on their total area up to 250 kg of nitrogen from livestock manure per hectare in the form of livestock manure originating from grazing livestock. In May 2014, a derogation decision was issued for the period until the end of December 2017 (EU, 2014). Stricter derogation conditions apply during this period. During this period, grassland farms cultivating at least 70% of their total area as grassland were 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. Farms on sandy and loessial soils in the provinces of Overijssel, Gelderland, Utrecht, North Brabant and Limburg are permitted to apply up to 230 kg of nitrogen per hectare in the form of livestock manure originating from grazing livestock. As of 15 May 2014, farms participating in the derogation scheme are no longer permitted to import phosphate-containing fertilisers. On 31 May 2018, a new derogation decision with additional conditions was issued for the period until the end of December 2019 (EU, 2018). One of these additional conditions is that if grassland is ploughed for grassland restoration or for maize cultivation, then the statutory application standard for nitrogen must be reduced for the area in question. As of 17 July 2020, a derogation decision was issued for the period until the end of December 2021 (EU, 2020). This report deals with the 2019 monitoring year and is therefore subject to the conditions of the 2018 derogation decision.

1.2 Research question, approach and scope

The present report compiled by RIVM and Wageningen Economic Research, together with the '2020 Dutch fertiliser policy report' of the Netherlands Enterprise Agency ('Rapportage Nederlands mestbeleid 2020'; RVO, 2021), fulfils the following obligations under the derogation decision (2018):

Article 9 Monitoring

9.1 The competent authorities shall ensure that maps are prepared with:

- *a for each municipality, the percentage of grassland farms for which a derogation permit has been granted;*
- *b for each municipality, the percentage of animals for which a derogation permit has been granted;*
- *c for each municipality, the percentage of agricultural land for which a derogation permit has been granted.*

These maps are updated annually.

This obligation is fulfilled via the '2020 Dutch fertiliser policy report' (RVO, 2021).

9.2 *The competent authorities shall establish a monitoring network for the sampling of groundwater, watercourses, shallow groundwater layers and drainage water at monitoring locations on grassland farms that benefit from derogation and shall maintain this network. The monitoring network must provide data on nitrate and phosphorus concentrations in the water leaching from the root zone and that ends up in the groundwater and surface water systems.*

9.3 *The monitoring network shall include at least 300 derogation farms and shall be representative of all soil types (clay, peat, sand, and sandy loessial soils), fertilisation practices and crop rotations. The composition of the monitoring network shall not be modified during the period of applicability of this Decision.*

These obligations are complied with via the derogation monitoring network as part of the Minerals Policy Monitoring Programme together with the annual monitoring reports such as this report. The design of the derogation monitoring network is described in Chapter 2. 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.

9.4 *The competent authorities shall carry out a study and an ongoing nutrient analysis programme that provide data on the local land use, the crop rotation, and the agricultural practices for grassland farms that benefit from derogation. These data can be used for model-based calculations of the magnitude of nitrate leaching and phosphorus losses from fields where up to 230 kg or up to 250 kg of nitrogen in the form of manure from grazing livestock is applied per hectare per year.*

This obligation is complied with via this monitoring report, in which 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 arising from a number of factors, including a difference in the approach taken by the LMM and the RVO (Netherlands Enterprise Agency).

9.5 *The competent authorities shall intensify the water monitoring activities on agricultural catchments in sandy soils.*

This obligation is complied with as the geographical distribution of the derogation monitoring network is such that 160 of the 300 targeted farms are located in the Sand Region (see section 2.4).

Article 10 Controls and inspections

10.1 The competent authorities shall carry out administrative controls on all applications for derogation to check whether the conditions in articles 7 and 8 are complied with. If it becomes clear that these conditions are not complied with, then the application shall be denied and the applicant will be informed of the reasons for the denial.

The competent authorities shall carry out administrative controls on at least 5% of the grassland farms that benefit from derogation to verify the land use, the livestock numbers, and the production of animal manure.

10.2 The competent authorities shall establish an on-site inspection programme, on the basis of a risk assessment and of an appropriate frequency, for the grassland forms that benefit from derogation, taking into account the results of the controls carried out in previous years, the results of the general random controls required by Directive 91/676/EEG and any other information that could indicate that the conditions of articles 7 and 8 are complied with.

On-site inspections shall be carried out on at least 5% of the grassland farms that benefit from derogation to evaluate whether the conditions of articles 7 and 8 are being complied with. The inspections shall be supplemented by the inspections and controls referred to in article 4 under 2c.

10.3 If it becomes clear, in a particular year, that a grassland farm that has been granted a permit did not comply with the conditions of articles 7 and 8, then a penalty will be imposed on the permit holder in accordance with the national regulations, and the holder will be no longer be eligible for derogation in the following year.

10.4 The competent authorities will be provided with the necessary authorities and resources to verify compliance with the conditions that apply to a permit granted on the basis of this decision.

The results of these controls shall be presented in the '2020 Dutch fertiliser policy report' (RVO, 2021).

Article 11 Reporting

11.1 The competent authorities shall submit to the Commission every year no later than 30 June a report containing the following information:

- *a data related to fertilisation on all grassland farms which benefit from an individual derogation, including information on yields and on soil types;*
- *b trends in livestock numbers for each livestock category in the Netherlands and on 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 the national level;*

e the maps referred to in article 9 section 1;
f the results of the water monitoring, including information on water quality trends for ground and surface water, as well as the impact of the derogation granted via this decision on the water quality;
g the data on the nitrate and phosphorus concentration referred to in article 9, section 2;
h the results of the intensified water monitoring programme referred to in article 9, section 5;
As their primary goal is to reach worldwide estimates in their Global Burden of Disease project, generic methods are used to ensure that the data and results between countries are comparable. the results of the investigations carried out into the local land use, the crop rotation, and the agricultural practices referred to in article 9, section 4;
j the results of the model-based calculations referred to in article 9, section 4;
i=0 an evaluation of the implementation of the derogation conditions specified in articles 7 and 8, on the basis of controls at farm level and information on non-compliant farms, on the basis of the results of the administrative controls and on-site inspections as referred to in article 10;
l the results of the intensified enforcement strategy referred to in article 4, in particular with regard to reducing the number of cases of non-compliance.

The present report may be regarded as the report referred to in Article 11 as cited above. Data on controls and instances of non-compliance are presented in the '2020 Dutch fertiliser policy report' (RVO, 2021). In consultation with the European Commission, these reports are submitted in June, as was the case for previous years.

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 information on the average use of fertiliser on all derogation farms in the Netherlands, determined according to data from the LMM and Netherlands Enterprise Agency. Differences between both these sources can occur as a result of differences in their underlying goal and the specific population of farms involved. The obligation in 11.1d is fulfilled via the '2020 Dutch fertiliser policy report' (RVO, 2021). Section 3.1.1 specifies the use of nitrogen in manure and fertilisers by crop and soil type.

11.2 The spatial data contained in the report shall, where applicable, fulfil the provisions of Directive 2007/2/EC. In collecting the necessary data, the Netherlands makes use, where appropriate, of the information generated under the Integrated Administration and Control System established pursuant to article 67, section 1 of Regulation (EU) no. 1306/2013.

1.3 Previously published reports and contents of this report

This is the 15th annual report setting out the results of the derogation monitoring network. This report presents information on the use of fertiliser, 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 from 2008 up to and including 2010. 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 and 2014, Lukács *et al.*., 2015 and 2016 and Hooijboer *et al*., 2017, Lukács *et al*., 2018, 2019 and 2020). Once results for multiple measurement years became available, the reports devoted more attention to the examination of trends in agricultural practices and water quality.

Chapter 2 describes the design and implementation of the derogation monitoring network. It also provides the agricultural characteristics of the participating farms (see section 2.7). Section 2.8 describes the soil characteristics of the participating farms.

Chapter 3 presents and discusses the measurement results of the monitoring of agricultural practices and water quality for 2019. This chapter also contains the provisional water quality monitoring results for 2020 (see section 3.2.4).

Chapter 4 describes developments related to agricultural practices and water quality. This includes a discussion of trend-based changes since the start of the derogation scheme as well as an analysis of the extent to which the last year differed from previous years. The effects of drought on water quality are also considered. In addition, an assessment is provided of the effects of agricultural practices on water quality.

2 Design of the derogation monitoring network

2.1 General

The design of the derogation monitoring network must satisfy the requirements of the European Commission, as stipulated in the derogation decision of December 2005, the extension of the derogation granted in 2010, and the derogation decisions of May 2014, 2018, and 2020 (refer to sections 1.1 and 1.2). Previous reports provided extensive information about the composition of the sample and the choices this entailed (Fraters en Boumans, 2005; Fraters *et al*., 2007b, De Goffau *et al.*, 2012).

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, i.e. the Minerals Policy Monitoring Programme (LMM). Water quality and agricultural practices at farms selected for this purpose have been monitored under the LMM programme since 1992 (Fraters and Boumans, 2005, De Goffau *et al.*, 2012, Vliet *et al.,* 2017, Van Duijnen *et al.,* 2021). 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 the Farm Accountancy Data Network (FADN) (Poppe, 2004). Appendix 2 provides a description of the monitoring of the agricultural characteristics and the calculation methods for fertiliser usage and nutrient surpluses. Water samples on farms were taken in accordance with the standard LMM procedures (Fraters *et al*., 2004, De Goffau *et al.,* 2012, Vliet *et al.,* 2017, Van Duijnen *et al.*, 2021). 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 of the Nitrate 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% of the approx. 1.85 million hectares of agricultural land in the Netherlands (Statistics Netherlands Agricultural Census, data processed by LEI, 2014). The acreage of agricultural land in the Loess Region accounts for approx. 1.5% of all agricultural land in the Netherlands, while the acreage in the Clay Region accounts for approx. 41% and the Peat Region for approx. 10.5%.

The data reported in the Sand Region makes a distinction according to the maximum derogation which may be applied for by farms. Starting in 2014, farms on sandy and loess soils in the provinces of Overijssel, Gelderland, Utrecht, North Brabant and Limburg were allowed to apply up to a maximum of 230 kg of nitrogen per hectare per year in the form of grazing livestock manure. Farms on other soils and on sandy soils in other provinces may apply up to 250 kg of nitrogen per hectare per year in the form of grazing livestock manure. In this report, the Sand Region is further divided into two sub-regions called ‘Sand-230’ and ‘Sand-250’. The Sand-230 sub-region is defined as the part of the Sand Region located in the provinces mentioned above. The Sand-250 sub-region is defined as the other part of the Sand Region (also see Figure B1.1 in Appendix 1). Farms in the Sand-230 sub-region and the Loess Region are therefore permitted to apply up to a maximum of 230 kg of nitrogen per hectare per year on their sandy and loess soils in the form of grazing livestock manure. If a farm also has one or more fields on peat or clay soil, it can apply up to 250 kg nitrogen per hectare in the form of grazing livestock manure on these fields.

In addition, farms participating in the derogation monitoring network that also participate in the ‘Koeien en Kansen’ (Cows and Opportunities) project are treated differently. ‘Koeien en Kansen’ (K&K) is a research project in which the effects of the future manure policy are investigated. K&K derogation farms are allowed to apply 250 kg of nitrogen per hectare in the form of grazing livestock manure on all their fields, regardless of which region they are located in. A total of 14 K&K farms participate in the derogation monitoring network. Of these 14 farms, 4 four are located in Sand-230 and 1 in the Loess Region. In the reporting of the results, these farms are included in the region where they are actually located.

Six Cows and Opportunities farms participate in the BES project (Farm-specific nitrogen standard) of *Wageningen University & Research*. The EU standard for the maximum release of nitrogen from livestock manure does not apply to these farms due to the requirements of the research project they are involved in. However, they do have to meet the application standards for nitrogen and phosphate. Due to the different regulations that apply to these farms, their results in the area of minerals management and water quality are not included in this report.

The LMM calculations are aimed at calculating the fertilisation rates as accurately as possible, using as much farm-specific information as possible. The fertiliser usage on derogation farms calculated by the LMM and the Netherlands Enterprise Agency (RVO) may differ from each other; also see Appendix 5. It is explicitly not the goal of the LMM to monitor compliance with statutory fertilisation requirements. Differences may exist, for example, with regard to the area of cultivated land, (farm-specific) excretion, and other points of departure.

Weighting of data on agricultural practices
Starting with this report, the data on agricultural practices was weighted on the basis of derogation network stratification (see Appendix 6). The surface areas of farms in the derogation monitoring network turned out to be systematically higher in comparison to the Agricultural Census. The analysis described in Appendix 6 makes it clear that weighting on the basis of derogation monitoring network stratification results in the smallest standard errors. The deviation in the surface area under cultivation in comparison to the Agricultural Census is then also the smallest. No weighting was carried out for the water quality data, as weighting (on the basis of surface areas) has practically no effect on the results (see Appendix 6).

No monitoring of ammonia emissions in the derogation monitoring network
As the derogation monitoring network focuses specifically on the monitoring of water quality in relation to the agricultural practices, the monitoring of ammonia emission was excluded from this report. The Netherlands reports annual figures on ammonia emission to the European Commission within the framework of the revised NEC guideline 2016 (EU, 2016). The national emission ceilings for air pollutants, including ammonia, are set down in this NEC guideline. The most recent figures are available in the '*Informative Inventory Report 2021'* (Wever *et al.,* 2021).

2.2 Statistical method used to determine deviations and trends

Determination of deviations in the measurement year under consideration
The purpose of the comparison is to determine whether a selected variable, for example fertiliser application or nitrate concentration, in the measurement year under consideration significantly deviates from the average value over the previous 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 water quality data and agricultural practice data were processed using the *Linear Mixed Effect Procedure* within R, version 4.0.2.

Calculations were made using weighted annual averages per farm for the agricultural practices data and unweighted annual averages per farm for the water quality data (see Appendix 6). All available annual farm averages were divided into two groups, with Group 1 comprising all the figures for the measurement year concerned, and Group 2 comprising all averages for the preceding years. The difference between Group 1 and Group 2 was subsequently estimated as a so-called '*fixed effect*', taking into account the fact that some data were not derived from the same farms, the '*random effect'*.

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 a 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. see Appendix 4, Table B4.1B).

Determination of trends
In addition, a determination is made as to whether a significant trend exists over the entire measurement period (p <0.05). The REML method was used for this purpose as well, with the annual average concentrations per farm and, when appropriate, per soil type region being grouped together.

2.3 Water quality and agricultural practices

The water quality in terms of nitrate concentration measured in any year partly reflects agricultural practices in the year preceding the water quality monitoring and in previous years. The extent to which agricultural practices in previous years affect the water quality measurements depends on various factors, including the size and fluctuation of the precipitation surplus during that year. The local hydrological circumstances also have an effect. In the High Netherlands, it is assumed that agricultural practices continue to have an effect on water quality for at least one year. In the Low Netherlands, the impact of agricultural practices on water quality is quicker to materialise. The 'Low Netherlands' comprises the Clay Region, the Peat Region and 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. This difference in hydrological conditions (rate of leaching) also explains the different sampling methods and sampling periods employed in the Low Netherlands and High Netherlands (see Appendix 3).

In the Low Netherlands, water quality is determined in the winter season (November until April) following the year (the growing season) in which the agricultural practices were determined. 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 2019 can be related to agricultural practices in 2018 (see Table 2.1). Water quality samples for measurement year 2019 were taken during the winter of 2018/2019 in the Low Netherlands, and during the summer and autumn of 2019 in the High Netherlands.

The present report also includes water quality sampling results for measurement year 2020, which can be related to agricultural practices in 2019 (see Table 2.1). These water samples were taken in the winter of 2019-2020 in the Low Netherlands, and in the summer of 2020 in the High Netherlands. The results for the Loess Region from sampling carried out in the autumn of 2020 are not yet available, and the other data are regarded as provisional because it is unknown at this time which farms will qualify for participation in the derogation scheme in 2020. The final figures for 2020 will be reported in 2022, at which time the 2020 data for the Loess Region will also be available and finalised.

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

Reporting	**Agricultural practices**	**Water quality**[2]		
		Clay and Peat	**Sand**	**Loess**
Lukács *et al*., 2020	2018	2017/2018 final, 2018/2019 provisional	2018 final, 2019 provisional	2018/2019 final, 2019/2020 not yet known
Van Duijnen *et al*., 2021[1]	2019	2018/2019 final, 2019/2020 provisional	2019 final, 2020 provisional	2019/2020 final, 2020/2021 not yet known

[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.

The nitrate concentrations are compared to the EU standard of 50 mg/l. This standard applies to groundwater and not to soil moisture, i.e. to water present in soil that is not saturated. Almost all measurements of water leaching from the root zone in the Loess Region and a limited number of measurements in the Sand region apply to nitrate concentrations in soil moisture collected between 1.5 m and 3 m below ground level.. This is because the groundwater (i.e. the water-saturated zone) at these locations is found at great depths, often tens of metres below surface level. This groundwater is therefore not representative of the water leaching from the root zone in farms. Strictly speaking the EU standard does not apply to soil moisture, but the Netherlands nevertheless reports the concentration in the soil moisture for the Loess Region.

2.4 Correction of nitrate figures for weather conditions and sampling

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 input 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 changes in groundwater levels (Boumans *et al.*, 2005; Fraters *et al.*, 2005; Zwart *et al.*, 2009; Zwart *et al.*, 2010; Zwart *et al.*, 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).

The nitrate concentrations actually measured are presented in this report, but in order to be able to differentiate between the effects of agricultural policy and the effects of environmental factors, a statistical method was developed for the Sand Region to standardise the nitrate concentration measured for the influence of weather conditions, groundwater level, and changes in sampling (Boumans and Fraters, 2011). This method uses relative evaporation as a yardstick for the impact of annual fluctuations in the precipitation surplus. Nitrate concentrations will rise as evaporation increases and groundwater levels decrease, provided other factors do not change. For a further explanation of the method, we refer the reader to Hooijboer *et al.* (2013; see Appendix 6). The method was improved in 2016 by making use of more detailed precipitation and evaporation data, by using summer and winter measurements, and by taking into account the sampling month (Boumans and Fraters, 2017). The indicator for the precipitation surplus is calculated using the SWAP model (Van Dam *et al*., 2008). This method does not take all the processes into consideration that have an influence on the nitrate concentration, and is based on correlations. This improved method is also suitable for standardising the nitrate concentrations in the Clay Region.

The standardised nitrate concentrations presented in this report are in line with those in the reports published on 2017 and earlier years. However, they differ slightly from the numbers presented in last year's report (Lukács *et al.*, 2020), as the calculation of the indicator for the precipitation surplus in 2020 was done using a different method. This discrepancy was corrected in the report at hand.
In section 4.2.2, the changes over time in the nitrate concentrations measured in the water leaching from the root zone in Sand-230, Sand-250, and the Clay Region are compared to the standardised nitrate concentrations.

2.5 Number of farms in 2019

2.5.1 Number of farms where agricultural practices were determined

The derogation monitoring network is a fixed monitoring network. Nevertheless, a number of farms 'drop out' every year because they are no longer participating in the LMM programme or do not apply for or are no longer registered for inclusion in the derogation monitoring network. 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 third parties, so that data on the input and output of feedstuffs, animals and manure is by definition incomplete. In addition, other improbable data may have been identified in the registration of inputs and/or outputs. In these cases, however, water quality samples have been taken.

Agricultural practices were successfully registered at 297 of the 300 planned farms (see Table 2.2). Of these 297 farms, 295 actually participated in the derogation scheme. Complete nutrient flow data was submitted for 286 farms out of the total of 295 farms benefiting from derogation. Six these 286 farms were excluded from consideration due to their participation in the BES pilot. Accordingly, the results presented in this derogation report are based on the data for 279 farms. 21 farms that participated in the derogation monitoring network in 2018 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 2019 (agricultural practices)

Farm type	Planned/Actual	Sand 250	Sand 230	Loess	Clay	Peat	Total
Dairy farms	Planned	140		18	54	54	266
	Actual:						
	- Of which were processed	43	96	17	54	52	262
	- Of which participated in the derogation scheme	43	96	17	54	50	260
	- Of which submitted complete nutrient flow data	43	94	16	53	49	255
	- Of which not part of BES pilot and complete nutrient flow data available	43	93	16	50	47	249
Other grassland farms	Planned	20		2	6	6	34
	Actual:						
	- Of which were processed	3	16	3	6	7	35
	- Of which participated in the derogation scheme	3	16	3	6	7	35
	- Of which submitted complete nutrient flow data	3	11	3	6	7	30
	- Of which not part of BES pilot and complete nutrient flow data available	3	11	3	6	7	30
Total	Planned	160		20	60	60	300
	Actual:						
	- Of which were processed	46	112	20	60	59	297
	- Of which participated in the derogation scheme	46	112	20	60	57	295
	- Of which submitted complete nutrient flow data	46	105	19	59	56	285
	- Of which not part of BES pilot and complete nutrient flow data available	46	104	19	56	54	279

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

- The description of general farm characteristics (see section 2.7) concerns all farms that could be fully processed in FADN in 2019 and that participated in the derogation scheme (295 farms; see Table 2.2).
- The description of agricultural practices in 2019 (see section 3.1) concerns all farms for which a full picture of nutrient flows could be obtained from FADN data and that did not participate in the BES pilot (279 farms; see Table 2.2).
- The comparison of agricultural practices in the 2006-2019 period (see 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 B4.2A).

2.5.2 *Number of farms where water quality was sampled*

In 2019, the water quality was sampled on 300 farms (see Table 2.3). Of these 301 farms, 280 participated in the derogation monitoring network in 2019. The difference in 20 farms is caused by changes in the derogation monitoring network. As a result, samples were taken at a number of farms that later dropped out for measurement year 2019. However, the farms that dropped out have been used to determine trends in water quality. Three farms out of the 280 farms in the derogation monitoring network that were sampled did not make use of the derogation and six farms participated in the BES pilot and were therefore not included in this report. The water quality sampling results of the remaining 271 sampled farms are presented in this report.

Table 2.3 Planned and actual number of analysed dairy and other grassland farms per region in 2019 (water quality)

Farm type	**Planned/Actual**	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
		250	**230**				
Dairy farms	Planned	140		17	52	52	261
	Actual:						
	- sampled	46	95	18	54	50	263
	- Derogation monitoring network 2019[1]	42	91	18	47	46	244
	- participated in derogation scheme[2]	42	90	18	44	42	236
Other grassland farms	Planned	20		3	8	8	39
	Actual:						
	- sampled	2	17	2	6	10	37
	- Derogation monitoring network 2019[1]	2	16	2	6	10	36
	- participated in derogation scheme[2]	2	15	2	6	10	35
Total	Planned	160		20	60	60	300
	Actual:						
	- sampled	48	112	20	60	60	300
	- Derogation monitoring network 2019[1]	44	107	20	53	56	280
	- participated in derogation scheme[2]	44	105	20	50	52	271

[1] Samples are often taken at farms before the composition of the derogation monitoring network is known (and certain farms have dropped out). However, the farms that have dropped out are used to determine trends.
[2] Excluding farms that participated in the BES pilot

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

- The description of the water quality results for measurement year 2019 (see section 3.2) concerns all farms where water quality samples were taken in 2019 and that were granted derogation in 2019 with the exception of the farms that participated in the BES-pilot (271 farms; see Table 2.3).
- The description of the water quality results for measurement year 2020 (see section 3.2.4) concerns all farms participating in the

derogation monitoring network in 2019 (except farms in the Loess Region) where water quality samples were taken in measurement year 2020 with the exception of the farms that participated in the BES-pilot in 2020 (274 farms; see Table 2.5).

- The analysis of water quality during the period from 2007 up to and including 2020 (see section 4.2.1) concerns all farms that participated in the derogation monitoring network in the agricultural practice year preceding the relevant measurement year, and that were granted derogation in that previous year. This number varies from year to year (see Table 2.4). The water quality data for the BES farms are excluded from the trendline starting from the year in which they joined the BES pilot, even though they were still granted derogation in those years.

Depending on the soil type region, samples were taken of water leaching from the root zone (groundwater, drain water or soil moisture) and, when possible, ditch water (see Table 2.4, Table 2.5, and Appendix 3).

Table 2.4 Number of farms per year that was used for determining trends in water quality; these farms were granted derogation in the year preceding the relevant measurement year

Year	**Number of farms leaching**	**Number of farms ditch water**
2007	271	141
2008	274	142
2009	277	146
2010	273	145
2011	273	145
2012	276	143
2013	297	156
2014	288	145
2015	288	146
2016	295	147
2017	296	150
2018	287	147
2019	289	143
2020[1]	271	143

[1] With the exception of the derogation farms in the Loess Region. The data for the autumn of 2020 are not yet available.

Table 2.5 Number of farms that were sampled and reported on per region for 2019 and 2020, and the sampling frequency of the leaching water and ditch water rounds; the planned sampling frequency is shown between parentheses

Year		**Sand**		**Loess**	**Clay**	**Peat**	**Total**
		250	**230**				
2019	Number of farms	44	105	20	50	52	271
	Number of farms – Leaching water	44	105	20	50	52	271
	Number of rounds - Leaching water	1.0 (1)	1.0 (1)	1.0 (1)	2.5 (2-4)[1]	1.0 (1)	
	Number of farms – Ditch water	11	20	-	49	51	131
	Number of rounds - Ditch water	3.5 (4)	3.9 (4)	-	3.5 (4)	3.4 (4)	
2020	Number of farms	46	113	-[2]	57	58	274
	Number of farms – Leaching water	46	113	-	57	57	273
	Number of rounds - Leaching water	1.0 (1)	1.0 (1)	-	3.1 (2-4)	1.0 (1)	
	Number of farms – Ditch water	12	21	-	56	57	145
	Number of rounds - Ditch water	4.0 (4)	4.0 (4)	-	3.9 (4)	3.9 (4)	

[1] In the Clay Region, groundwater is sampled up to two times, and drain water is sampled 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 drain water sampling.
[2] The autumn 2020 data for the derogation farms in the Loess Region were not yet available when this report was being prepared.

2.6 Representativeness of the sample of farms

295 farms participating in the derogation monitoring network were known to have been registered for derogation in 2019. These farms have a combined total acreage of 18,900 hectares (accounting for 2.4% of all agricultural land on grassland farms in the Netherlands; see Table 2.6). The sample represents 90% of the farms and 98% of the acreage of all farms that registered for derogation in 2019 and that satisfied the LMM selection criteria (refer to Appendix 1). Farms not included in the sample population which did register for derogation are mainly other grassland farms with a size of less than 25,000 Standard Output (SO) units.

Section 2.1 explains that the Sand Region has been subdivided into the 'Sand-250' and 'Sand-230' sub-regions starting in 2014. Although this distinction has not been taken into account in the selection of farms, Table 2.6 shows that the representativeness of the sample in both sand regions is not jeopardised. In 2019, in both regions, 3.1% and 2.3%, respectively, of the area of cultivated land covered by the derogation was included in the sample. That percentage amounts to 2.4% for the entire derogation monitoring network.

Furthermore, in all regions the proportion of sampled to total acreage is greater on dairy farms than on other grassland farms. This is because, 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 selected are slightly smaller than the dairy farms in terms of their acreage of cultivated land.
The Loess Region is relatively small, and it contains relatively few farms compared to the larger regions. Because the study requires a minimum number of observations per region, a relatively large part of the area sampled in the Loess Region (23%) is located in the derogation 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 2019 in the sample population, according to the 2019 Agricultural Census

Region	Farm type	Sample population[1]	Derogation monitoring network	
		Acreage (hectares)	Acreage (hectares)	% of acreage sample population
Sand 250	Dairy farms	111,052	3,585	3.2
	Other grassland farms	8,771	104	1.2
	Total	119,823	3,690	3.1
Sand 230	Dairy farms	218,779	5,215	2.4
	Other grassland farms	31,057	437	1.4
	Total	249,836	5,652	2.3
Loess	Dairy farms	4,015	966	24
	Other grassland farms	483	78	16
	Total	4,498	1,043	23
Clay	Dairy farms	246,940	4,232	1.7
	Other grassland farms	22,972	176	0.8
	Total	269,912	4,408	1.6
Peat	Dairy farms	137,531	3,797	2.8
	Other grassland farms	14,321	309	2.2
	Total	151,852	4,107	2.7
All	Dairy farms	718,317	17,795	2.5
	Other grassland farms	77,604	1,105	1.4
	Total	795,921	18,900	2.4

[1] Estimate based on the 2019 Agricultural Census performed by Statistics Netherlands, (data processed by Wageningen Economic Research). 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 registered for derogation had an average of 54 hectares of cultivated land, of which 87% consisted of grassland. The average livestock density was 2.4 Phosphate Livestock Units (LSUs) per hectare (see Table 2.7). Farm data derived from the 2019 Agricultural Census have been included for purposes of comparison, in so far as these farms are in the sample population (see Appendix 1).

A comparison of the structural characteristics of the population of farms in the derogation monitoring network with the Agricultural Census data (see Table 2.7) shows that the farms in the derogation monitoring network use 5% more cultivated land on average than the overall population of farms. As the average grazing livestock density in Livestock Units per hectare on the farms in the derogation monitoring network is approximately 8% lower, the number of cattle on these farms is on average approximately 4% lower than for the overall population of farms.

This year, a weighting on the basis of the stratification variables ensured that the derogation monitoring network is more in line with the overall agricultural census data. For more information, see Appendix 6.

Table 2.7 Overview of a number of general farm characteristics in 2019 of farms participating in the derogation monitoring network (DMN), compared to average values for the Agricultural Census (AC) sample population

Farm characteristics[1]	**Population**	**Sand 250**	**Sand 230**	**Loess**	**Clay**	**Peat**	**Total**
Number of farms in DMN	DMN	46	112	20	60	57	295
Grassland area (hectares)	DMN	52	35	37	54	51	46
	AC	53	35	37	52	49	45
Area used to cultivate silage maize (hectares)	DMN	8.7	6.6	6.6	5.4	3.2	6.1
	AC	7.7	6.0	5.5	4.7	3.8	5.4
Other arable land (hectares)	DMN	2.6	1.2	2.2	1.5	1.6	1.4
	AC	0.6	0.5	1.5	0.9	0.3	0.6
Total area of cultivated land (hectares)	DMN	64	43	46	60	56	54
	AC	61	42	44	58	54	51
Percentage of grassland	DMN	85	84	84	90	94	88
	AC	86	84	81	89	91	87
Natural habitats (hectares)	DMN	1.4	1.1	0.7	4.3	1.0	2.1
	AC	0.2	0.1	0.0	0.2	0.1	0.1
Grazing livestock density (Phosphate LSUs/ per hectare) [2]	DMN	2.0	2.4	2.2	2.1	2.2	2.2
	AC	2.1	2.6	2.5	2.3	2.1	2.4
Percentage of intensive livestock farms	DMN	1.9	9.2	0.0	2.6	7.1	5.8
	AC	2.1	2.6	2.5	2.3	2.1	2.4
Grazing livestock density (Phosphate LSUs/ha)[2]							
Dairy cattle (including young livestock) (Phosphate LSUs/ per hectare)[2]	DMN	2.0	2.3	2.1	2.0	2.0	2.1
Other grazing livestock (Phosphate LSUs/ per hectare)[2]	DMN	0.0	0.1	0.1	0.1	0.2	0.1
Intensive livestock (total) (Phosphate LSUs per hectare)[2]	DMN	0.1	0.4	0.0	0.2	0.1	0.2
All animals (Phosphate LSUs/ per hectare)[2]	DMN	2.1	2.8	2.2	2.3	2.3	2.4

Source: Statistics Netherlands Agricultural Census 2019, data processed by Wageningen Economic Research and FADN.
[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, 2000). The standard phosphate production of one dairy cow is equivalent to one Phosphate Livestock Unit.

The weighted average of the national sample for the Dutch part of the *Farm Accountancy Data Network* of the European Commission (FADN) has been used to determine the extent to which a number of the characteristics of dairy farms participating in the derogation monitoring network deviate from those of other dairy farms, as the Agricultural Census does not provide appropriate data for such a comparison. The comparison (see Table 2.8) makes it clear that the dairy farms in the derogation monitoring network produce on average 50,000 kg more milk. If we look at the regions, then the Sand-250 and Peat regions have a higher milk production per farm than the national averages. In Sand-230 the milk production per dairy farm in the derogation monitoring network is practically the same as the national average and in the Clay Region a bit less. A similar comparison could not be carried out for the Loess Region due to an insufficient number of FADN-registered farms.

The average production of Fat and Protein Corrected Milk (FPCM) on the dairy farms in the derogation monitoring network is 17,800 kg, which is a bit less than the national average of 18,200 kg based on FADN data. On average, derogation dairy farms in the Sand-250 and Peat regions produce more Fat and Protein Corrected Milk per hectare than FADN-registered farms, whereas in the Sand-230 and Clay regions the opposite is true. There are also differences in terms of the grazing characteristics. Particularly in the Sand-250 and Clay regions, the farms in the derogation monitoring network appear to make more use of grazing than in the national sample.

Table 2.8 Average milk production and grazing periods on dairy farms participating in the derogation monitoring network (DMN) in 2019, compared to the weighted average for dairy farms in the national FADN sample

Farm characteristic	**Population**	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
		250	**230**				
Number of farms in DMN	DMN	43	96	17	54	50	260
kg FPCM[1]/farm (x1,000 kg)	DMN	1,070	952	872	1,105	1,012	1,027
	FADN	1,004	951		1,149	866	976
kg FPCM[1]per hectare of fodder crop	DMN	16,700	19,700	17,600	16,700	17,500	17,800
	FADN	15,900	20,500		18,100	16,400	18,200
FPCM production in kg[1] per dairy cow	DMN	9,700	9,800	9,800	9,200	9,300	9,500
	FADN	9,600	9,700		9,600	8,800	9,500
Percentage of farms with grazing in May-October period	DMN	90	84	88	90	89	88
	FADN	85	81		84	91	84
Percentage of farms with grazing in May-June period	DMN	90	84	88	90	89	88
	FADN	85	81		84	91	84
Percentage of farms with grazing in July-August period	DMN	90	82	88	90	89	87
	FADN	85	77		84	91	83
Percentage of farms with grazing in September-October period	DMN	86	79	88	86	84	83
	FADN	82	75		77	85	79

[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% fat content and 3.32% protein content).

2.8 Characteristics of farms where water quality samples were taken

The sampled farms are distributed across the four soil type regions (see Table 2.9). These soil type regions are further subdivided into policy districts (see Appendix B1.6). Table 2.9 makes a distinction between dairy farms and other grassland farms.

Table 2.9 Distribution of the 280 grassland farms where water quality samples were taken in 2019 and that were selected for the derogation monitoring network in that year, over the different soil type regions and the districts for policy-making purposes

Soil type regions and districts for policy-making purposes	Dairy farms	Other grassland farms	Total
Sand-250	**42**	**2**	**44**
• Sand North	42	2	44
• Sand West	-	-	-
Sand-230	**91**	**16**	**110**
• Sand Central	71	11	82
• Sand South	20	5	25
Clay Region	**47**	**6**	**53**
• Marine Clay – North	17	2	19
• Marine Clay – Central	9	-	9
• Marine Clay – South-West	4	-	4
• River Clay	17	4	21
Peat Region	**46**	**10**	**56**
• Peatland Pastures – West	25	3	28
• Peatland Pastures – North	21	7	28
Loess Region	**18**	**2**	**20**

Within a particular region, other soil types occur in addition to the main soil type for which the region is named (see Tables 2.10 and 2.11).

The Loess Region mainly consists of soils with good drainage, whereas the Peat Region mainly consists of soils with poor drainage. The Sand Region consists mostly of soils with good drainage, but the derogation farms are located on relatively less well-drained soils in the Sand Region. Traditionally, the best soils (with favourable drainage conditions and nutrient status) were used for arable farming, while poorer (e.g. wetter) soils were used for dairy farming. In addition, the driest soils in the Sand Region are generally not used for agriculture. Wetter sandy soils are therefore over-represented in the derogation monitoring network.

On average, the farms in Sand-230 have a higher percentage of sandy soil (88%) than the farms in Sand-250 (78%). The farms in Sand-230 are on average also located more on clay soil. The farms in Sand-250 are located somewhat more on peat soil and wetland soil. The farms in Sand-230 have a higher percentage of well-drained soils as well as poorly drained soils in comparison to farms in Sand-250. Compared to the farms in Sand-230, the farms in Sand-250 are found more frequently on moderately drained soils.

The differences with respect to soil type and drainage class between 2019 and the provisional figures for 2020 are limited (see Table 2.10 and Table 2.11). Changes are due to shifts in farms included in the monitoring network. The figures for 2020 are provisional, as it was not yet known which farms actually made use of the derogation when this report was released.

Table 2.10 Soil type and drainage class (%) per region on the derogation farms sampled in 2019

Region	**Soil type**				**Drainage class[1]**		
	Sand	**Loess**	**Clay**	**Peat**	**Poor**	**Moderate**	**Good**
Sand-250	78	0	2	20	40	56	4
Sand-230	88	0	8	4	43	43	14
Loess Region	2	74	24	0	0	3	97
Clay Region	6	0	92	2	49	47	4
Peat Region	23	0	16	61	94	6	0

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

Table 2.11 Soil type and drainage class (%) per region on farms from the derogation monitoring network sampled in 2020

Region	**Soil type**				**Drainage class[1]**		
	Sand	**Loess**	**Clay**	**Peat**	**Poor**	**Moderate**	**Good**
Sand-250	77	0	2	21	41	55	4
Sand-230	87	0	9	4	45	42	13
Loess Region	-	-	-	-	-	-	-
Clay Region	5	0	93	2	48	49	3
Peat Region	23	0	18	59	93	7	0

[1] The drainage class is linked to the water table class (‘Grondwatertrap’, Gt). The ‘Poor natural drainage’ class comprises water table classes Gt I through Gt IV; the ‘Moderate drainage’ class comprises water table classes Gt V, V* and VI, and the ‘Good drainage’ class comprises water table classes Gt VII and Gt VIII.
* Results from the Loess Region were not yet available at the time the present report was being prepared.

3 Results

3.1 Agricultural characteristics

3.1.1 Nitrogen use in livestock manure

In 2019, the average use of nitrogen in livestock manure on derogation farms amounted to 230 kg/ha (including nitrogen in the manure excreted during grazing: see Table 3.1). The Loess Region had the lowest average amount of nitrogen from livestock manure being used: 206 kg/ha. The amount of nitrogen used in 2019 was the highest in the Peat Region, namely 244 kg/ha. In all regions, less nitrogen from livestock manure was applied on arable land (mainly land used for cultivation of silage maize) than on grassland. The farms in the derogation monitoring network both put in and put out livestock manure. As average manure production exceeded the permitted use in terms of nitrogen or phosphate, the average manure output exceeded the input (including stock changes). This was true of all regions (see Table 3.1).

Table 3.1 Average nitrogen use in livestock manure in the different regions (kg N/ha) in 2019 on farms participating in the derogation monitoring network

Description	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
	250	**230**				
Number of farms	46	104	19	56	54	279
Produced on farm[1]	249	297	254	262	270	271
+ Inputs	11	6	4	10	8	8
+ stock changes[2]	-1	-5	1	-1	-1	-2
– Outputs	29	75	53	42	32	48
Total amount used on farm	230	223	206	229	244	230
Use on arable land[3,4]	170	176	172	201	188	183
Use on grassland[3,5]	242	233	214	233	249	238

[1] Calculated on the basis of dairy farms that stated they were using the guidance document on farm-specific excretion by dairy cattle (N=162) with the exception of dairy farms that make use of standard-based excretion values (N = 117) (see Appendix 2).
[2] A negative change in stocks is a stock increase.
[3] The average use data for grassland and arable land is based on 269 farms and 203 farms, respectively, instead of on 279 farms. This is because on 10 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 66 farms had no arable land.
[4] The figures concerning use on arable land are reported by the farmer himself.
[5] Grassland usage levels are calculated by deducting the quantity applied on arable land from the total quantity applied.

The amount of livestock manure used in 2019 was less than in the previous years (see Appendix 4, Table B4.2). Farms in Sand-230 and the Loess Region are permitted to use 250 kg N/ha on their peat and clay soils, which can cause the average use to exceed 230 kg/ha. It should be noted that the LMM is explicitly not suitable for monitoring compliance with the statutory fertilisation requirements (also see section 2.1).

The average quantity of nitrogen in livestock manure produced on farms in the Sand-230 sub-region exceeded the average quantity in the Sand-250 sub-region by 48 kg N/ha. The output of nitrogen was also higher, as a result of which the use of nitrogen from livestock manure was 7 kg/ha lower in Sand-230 than in Sand-250. Approximately 18% of the farms in the derogation monitoring network did not put in or put out livestock manure (see Table 3.2). 17% of the farms put in livestock manure but did not put out any. These farmers probably put in livestock manure because this offered economic benefits compared to using inorganic fertilisers. This may also apply to the farmers who both put in and put out livestock manure (10%). The percentage of farms in the derogation monitoring network that only put out manure was 55%.

Table 3.2 Average percentage of farms participating in the derogation monitoring network with livestock manure inputs and/or outputs in 2019

Description	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
	250	**230**				
No inputs or outputs	28	9	17	19	26	18
Only outputs	28	72	63	56	40	55
Only inputs	21	14	10	16	24	17
Inputs and outputs	23	5	9	9	9	10

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

On average, the calculated total use of plant-available nitrogen on farms participating in the derogation monitoring network was lower than the nitrogen application standard in all regions in 2019 (see Table 3.3). On average, the farms participating in the derogation monitoring network applied 43 kg N/ha less than permitted by the nitrogen application standards. The use of livestock manure in particular decreased compared to 2018 (also see Table B4.3).

Table 3.3 Average use of nitrogen in fertilisers (in kg of plant-available N/ha)[1] on farms participating in the derogation monitoring network in 2019

Description	**Item**	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
		250	**230**				
Number of farms		46	104	19	56	54	279
Average statutory availability coefficient livestock manure (%)[1]		48	49	46	48	49	49
Use of plant-available nitrogen in:	Livestock manure	110	108	95	108	120	111
	Other organic fertilisers	0	0	0	0	0	0
	Inorganic fertilisers	107	117	100	152	110	126
	Average total	217	225	195	260	230	236
Nitrogen application standard		244	248	247	325	280	279
Use of plant-available nitrogen on arable land[2,3]		118	118	113	154	120	128
Application standard for arable land[2]		144	135	121	162	151	146
Use of plant-available nitrogen on arable land[2,4]		237	252	214	272	240	254
Application standard for arable land[2]		266	273	275	345	292	301

[1] Calculated on the basis of the applicable statutory availability coefficients (see Appendix 2). [2] The average use data for grassland and arable land is based on 269 farms and 203 farms, respectively, instead of on 279 farms. This is because on 10 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 66 farms had no arable land.
[3] The figures concerning use on arable land are reported by the farmer himself.
[4] Grassland usage levels are calculated by deducting the quantity applied on arable land from the total quantity applied.

In 2019, the average total use of phosphate on farms participating in the derogation monitoring network was lower than the average phosphate application standard of 84 kg per hectare (see Table 3.4). On average, 73 kg of phosphate was applied per hectare, of which 72 kg via livestock manure. As of 15 May 2014, inorganic phosphate-containing fertilisers were no longer allowed to be used on derogation farms. Table 3.4 makes it clear that there was nevertheless a limited use made of inorganic phosphate-containing fertilisers in 2 regions in 2019 (an average of 1 kg/ha). This is due to the classification of fertilisers in the LMM. For example, the use of nutrient concentrates was classified under inorganic fertilisers.

Table 3.4 Average use of phosphate in fertilisers (in kg of P_2O_5//ha) in 2019 on farms participating in the derogation monitoring network

Description	**Item**	**Sand 250**	**Sand 230**	**Loess**	**Clay**	**Peat**	**Total**
Number of farms		46	104	19	56	54	279
Phosphate use in:	Livestock manure	74	66	65	73	78	72
	Other organic fertilisers	0	1	1	1	0	1
	Inorganic fertilisers	1	0	0	1	0	0
	Average total	75	67	66	75	78	73
Phosphate application standard		85	80	86	85	87	84
Use of phosphate on arable land[1,2]		60	57	62	65	60	60
Application standard for arable land[1]		61	57	63	63	72	61
Use of phosphate on arable land[1,3]		78	69	67	75	80	75
Application standard for arable land[1]		90	86	92	88	89	88

[1] The average use data for grassland and arable land is based on 269 farms and 203 farms, respectively, instead of on 279 farms. This is because on 10 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 66 farms had no arable land.
[2] The figures concerning use on arable land are reported by the farmer himself.
[3] Grassland usage levels are calculated by deducting the quantity applied on arable land from the total quantity applied.

3.1.3 *Crop yields*

In 2019, the farms participating in the derogation monitoring network had an estimated average dry-matter yield of silage maize of 17,000 kg per hectare. This resulted in an estimated average yield of 205 kg of nitrogen and 30 kg of phosphorus (70 kg P_2O_5). The highest average yield realised was in the Clay Region, namely 18,600 kg dry matter per hectare. The lowest number recorded was in the Peat Region with 16,100 kg of dry matter per hectare (see Table 3.5). After a slightly lower yield of dry matter from silage maize in 2018 due to drought, the yield of dry matter in 2019 recovered somewhat (also see Table B4.5).

The grassland yield increased in 2019 in comparison to the dry year of 2018 in which low dry matter yields were realised on grassland, but still remained below the average dry matter yield in previous years (also see Table B 4.5). The calculated grassland yield amounted to 9,700 kg of dry matter per hectare on average. Due to a higher nitrogen concentration in grass than in maize, the yield of nitrogen per hectare for grassland was higher than for silage maize. The phosphorus yield for grass was 32 kg/ha, which was higher than for silage maize, 30 kg/ha.

In 2019, the calculated grassland dry-matter yields were the highest in the Peat Region and the lowest in Sand-250 (see Table 3.5).

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 2019 on farms participating in the derogation monitoring network that meet the criteria for application of the calculation me (Aarts et al.*, 2008)*

Description	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
	250	**230**				
Silage maize yields						
Number of farms	34	83	13	32	24	186
kg of dry matter per hectare	16,500	16,400	18,000	18,600	16,100	17,000
kg N/ha	199	205	213	216	188	205
kg P/ha	27	29	32	36	27	30
kg P_2O_5/ha	62	67	74	82	63	70
Grassland yields						
Number of farms	37	90	14	47	45	233
kg of dry matter per hectare	9,100	9,400	9,600	9,800	10,600	9,700
kg N/ha	250	253	243	270	298	268
kg P/ha	29	30	32	34	33	32
kg P_2O_5/ha	66	69	74	77	74	73

3.1.4 Nutrient surpluses

The calculated average nitrogen surplus on the soil surface balance of farms participating in the derogation monitoring network amounted to 156 kg per hectare in 2019, which marked a decrease compared to the average value recorded in previous years (see Table B4.6 in Appendix 4). The calculated input (nitrogen in ,amongst other things, feed and manure) was lower in 2019 than in 2018. The higher input in 2018 was due to the drought, which led to higher inputs of feed in particular due to depletion of the feedstocks. The calculated output (nitrogen in, amongst other things, livestock, milk and manure) in 2019 was similar to the level in 2018. The nitrogen surpluses on the soil surface balance showed considerable variation in 2019, including variation within each soil type region. The 25% of farms with the lowest surpluses realised a surplus of less than 108 kg N/ha, whereas the surplus exceeded 188 kg N/ha on the 25% of farms with the highest surpluses (see Table 3.6).

Table 3.6 Nitrogen surpluses on the soil surface balance (in kg N/ha) on farms participating in the derogation monitoring network in 2019 (average values and 25th and 75th percentile values per region)

Description	**Item**	**Sand 250**	**230**	**Loess**	**Clay**	**Peat**	**Total**
Number of farms		46	104	19	56	54	279
Farm inputs	Inorganic fertilisers	107	117	100	152	110	126
	Organic fertilisers	10	6	5	11	8	9
	Feedstuffs	173	251	198	180	175	199
	Animals	1	3	1	3	4	3
	Other	1	3	2	3	2	2
	Total	292	380	307	348	298	339
Farm outputs	Milk and other animal products	87	97	87	85	84	89
	Animals	10	28	12	19	18	20
	Organic fertilisers	28	76	52	42	33	48
	Other	19	18	33	16	20	18
	Total	143	218	184	162	156	175
Average nitrogen surplus per farm		149	162	123	187	143	164
+ Deposition, mineralisation and organic nitrogen fixation		44	32	39	30	118[1]	50
- Gaseous emissions[2]		52	58	46	61	57	58
Average nitrogen surplus on the soil surface balance[3]		140	136	116	156	204	156
25th percentile		100	98	87	108	151	108
75th percentile		174	171	166	185	253	188

[1] Based on the assumption of higher nitrogen mineralisation from organic matter on peat soil (see Appendix 2)
[2] Gaseous emissions resulting from stabling, storage, application and grazing
[3] Calculated in accordance with the method described in Appendix 2

The phosphate input calculated for 2019 was on average higher than the output. This means that the average calculated phosphate surplus on the soil surface balance was positive, namely 4 kg per hectare (see Table 3.7). The phosphate surplus per hectare decreased in comparison to 2018 when the calculated surplus on the soil surface balance was 16 kg/ha primarily due to the drought in 2018. The 25% of farms with the lowest phosphate surpluses realised a negative surplus of at least 9 kg per hectare in 2019, whereas the 25% of farms with the highest surpluses realised a minimum positive surplus of 14 kg per hectare.

Table 3.7 Phosphate surpluses on the soil surface balance (in kg P_2O_5 per hectare) on farms participating in the derogation monitoring network in 2019 (average values and 25th and 75th percentile values per region)

Description	Item	Sand 250	Sand 230	Loess	Clay	Peat	Total
Number of farms		46	104	19	56	54	279
Farm inputs	Inorganic fertilisers	1	0	0	1	0	0
	Organic fertilisers	4	3	2	4	3	3
	Feedstuffs	58	85	64	62	60	68
	Animals	1	2	1	2	3	2
	Other	0	1	1	1	0	1
	Total	63	91	68	69	66	74
Farm outputs	Milk and other animal products	34	38	34	33	32	35
	Animals	6	16	8	11	12	12
	Organic fertilisers	10	27	17	15	12	17
	Other	5	5	11	5	6	5
	Total	56	87	71	65	61	70
Phosphate surplus on soil surface balance: average[1]		8	4	-2	4	5	4
25th percentile		-4	-10	-12	-9	-8	-9
75th percentile		15	15	7	12	15	14

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

3.2 Water quality

3.2.1 Water leaching from the root zone, measured in 2019 (NO_3, N and P)

In 2019, in all regions with the exception of the Loess Region, the nitrate concentration was, on average, lower than the nitrate standard of 50 mg/l (see Table 3.8). The average nitrate concentration in the Loess Region was 59 mg/l.

There is a marked difference between the nitrate concentration in the water leaching from the root zone in Sand-230 (47 mg/l) and in Sand-250 (23 mg/l). This can be explained by the higher proportion of drier soils in the southern provinces (Sand-230). In addition, the northern provinces (Sand-250) contain more peat soils and wetland soils, which are associated with higher rates of denitrification.

The average nitrate concentration in the Peat Region was lower than in the Clay Region by more than half. The total nitrogen concentration, which also includes nitrate, was however comparable in the Peat Region to that in the Clay Region. This difference is caused by higher ammonium concentrations in groundwater in the Peat Region. The higher ammonium concentrations are probably due to the decomposition of organic matter in peat, whereby nitrogen is released in the form of ammonium (Butterbach-Bahl and Gundersen, 2011, Van Beek *et al*., 2004).

Groundwater that is or has been in contact with nutrient-rich peat layers often also has high phosphorus concentrations (Van Beek *et al*., 2004). These nutrient-rich peat layers may also contribute to the higher average phosphorus concentrations measured in the Peat Region and Clay Region compared to the concentrations measured in Sand-230 and Sand-250. In addition, phosphate ions are easily adsorbed by iron and aluminium oxides, and iron and aluminium hydroxides and clay minerals, particularly under aerobic (oxygen-rich) conditions such as those occurring in the Sand Region, as a result of which these ions do not end up in the groundwater. Phosphate also readily precipitates under aerobic conditions in the form of poorly soluble aluminium, iron and calcium phosphates.

The summer of 2018 was an especially dry summer, which in turn also had an effect on leaching and (nitrate) concentrations. The summer of 2019 was also drier than average, with marked local differences. This is dealt with in section 4.2.3.

Table 3.8 Nutrient concentrations in 2019 (in mg/l) in water leaching from the root zone on farms participating in the derogation monitoring network; average concentrations per region and percentage of observations below the phosphorus detection threshold (between parentheses)

Reference	**Sand-250**	**Sand-230**	**Loess**	**Clay**	**Peat**
Number of farms	44	105	20	50	52
Nitrate (NO_3)	23	47	59	44	16
Nitrogen[1] (N)	8.8	13	14	11	10
Phosphorus[2,3] (P)	0.22 (45)	0.1 (56)	<dt (80)	0.33 (26)	0.37 (12)

[1] Nitrogen was measured as total dissolved nitrogen. [2] The percentage of farms with average concentrations below the Detection Threshold (DT) is stated in parentheses. [3] The phosphorus concentration has been measured as the total amount of dissolved phosphorus.

In the Peat Region, the nitrate concentration in the water leaching from the root zone on approximately 88% of the farms was lower than the nitrate standard of 50 mg/l (see Table 3.9). In the Clay Region, over 62% of the farms had concentrations lower than the standard, and in the Sand 250 sub-region over 90% of the farms were below the standard.

In general, higher average nitrate concentrations were measured in the Sand-230 sub-region and Loess Region 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). There were also more farms in these regions that had higher concentrations, on average, than in the other regions (see Table 3.9).

Table 3.9 Frequency distribution (%) in 2019 of farm-specific average nitrate concentrations (in mg/l) in water leaching from the root zone on farms participating in the derogation monitoring network per region, expressed as percentages per class

Concentration class nitrate (mg/l)	**Sand-250**	**Sand-230**	**Loess**	**Clay**	**Peat**
Number of farms	44	105	20	50	52
< 15	48	15	5.0	20	65
15-25	16	9.5	15	6.0	13
25-40	18	20	0	22	9.6
40-50	9.1	16	20	14	0
>50	9.1	39	60	38	12

In 2019, the farms in the Loess Region had the highest median nitrogen concentration of all the regions; 50% of the farms in this region had a nitrogen concentration of 16 mg N/l or higher (see Table 3.10). The next highest median nitrogen concentrations were found in Sand-230 and the Clay Region, 12 mg N/l and 10 mg N/l respectively.

Table 3.9 Nitrogen concentrations1 (in mg N/l) in water leaching from the root zone in 2019 on farms participating in the derogation monitoring network; 25th percentile, median and 75th percentile values per region

Reference	**Sand-250**	**Sand-230**	**Loess**	**Clay**	**Peat**
Number of farms	44	105	20	50	52
First quartile (25th percentile)	5.5	9.0	9.8	6.8	6.9
Median (50th percentile)	7.5	12	16	10	8.1
Third quartile (75th percentile)	11	16	18	15	11

[1] Nitrogen was measured as total dissolved nitrogen.

The highest median phosphorus concentration in the water leaching from the root zone was measured in the Clay Region; 50% of the farms in the Clay Region had a phosphorus concentration higher than 0.18 mg P/l (see Table 3.11).

Table 3.11 Phosphorus concentrations1,2 (in mg P/l) in water leaching from the root zone on farms participating in the derogation monitoring network in 2019; 25th percentile, median and 75th percentile values per region

Reference	**Sand-250**	**Sand-230**	**Loess**	**Clay**	**Peat**
Number of farms	44	105	20	50	52
First quartile (25th percentile)	<DT	<DT	<DT	<DT	0.097
Median (50th percentile)	<DT	<DT	<DT	0.18	0.16
Third quartile (75th percentile)	0.12	0.1	<dt	0.34	0.33

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT. [2] The phosphorus concentration has been measured as the total amount of dissolved phosphorus.

3.2.2 *Ditch water quality, measured in winter 2018-2019*

Average nitrate concentration in ditch water in the winter was highest in Sand-230 at 65 mg/l, and lowest in the Peat Region at 12 mg/l (see Table 3.12). Total nitrogen concentrations, too, were highest in Sand-230 (16 mg N/l). The total nitrogen concentration in the Clay Region (6.5 mg N/l) was slightly higher than in the Peat Region (5.7 mg N/l). Phosphorus concentrations in ditch water were highest in the Clay Region and lowest in Sand-230.

Table 3.10 Average nutrient concentrations (in mg/l) in ditch water in the winter of 2018-2019 per region on farms participating in the derogation monitoring network and percentage of observations below the phosphorus detection threshold

Reference	Sand-250	Sand-230	Loess[1]	Clay	Peat
Number of farms	11	20	-	49	51
Nitrate (NO_3)	32	65	-	22	12
Nitrogen (N)	9.6	16	-	6.5	5.7
Phosphorus[3] (P)	0.15 (27)	0.1 (60)	-	0.17 (39)	0.12 (27)

[1] There are no LMM farms with ditches in the Loess Region. [2] Nitrogen was measured as total dissolved nitrogen. [3] Phosphorus was measured as total dissolved phosphorus. The percentage of farms with average concentrations below the Detection Threshold (DT) is stated in parentheses.

In Sand-230, 45% of the farms had ditch water nitrate concentrations higher than 50 mg/l (see Table 3.13). In the Peat Region, this was true of only 3.9% of the farms. In the Clay Region and Sand-250, 10% and 18% of the farms, respectively, had a nitrate concentration in ditch water that exceeded 50 mg/l.

Table 3.11 Frequency distribution (%) of farm-specific average nitrate concentrations (in mg/l) in ditch water per region on farms participating in the derogation monitoring network in the winter of 2018-2019, expressed as percentages per class

Concentration class nitrate (mg/l)	Sand-250	Sand-230	Loess[1]	Clay	Peat
Number of farms	11	20	-	49	51
< 15	27	5.0	-	49	80
15-25	18	5.0	-	22	9.8
25-40	27	35	-	12	3.9
40-50	9.1	10	-	6.1	2.0
> 50	18	45	-	10	3.9

[1] There are no LMM farms with ditches in the Loess Region.

The highest median concentration of nitrogen was found in Sand-230. Fifty percent of the farms in Sand-230 had ditch water nitrogen concentrations higher than 12 mg N/l (see Table 3.14).

Table 3.12 Ditch water nitrogen concentrations[1] (in mg N/l) measured in the winter of 2018-2019 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Reference	Sand-250	Sand-230	Loess[2]	Clay	Peat
Number of farms	11	20	-	49	51
First quartile (25th percentile)	5.4	8.9	-	3.4	3.7
Median (50th percentile)	9.0	12	-	5.3	4.8
Third quartile (75th percentile)	12	17	-	8.3	6.8

[1] Nitrogen was measured as total dissolved nitrogen. [2] There are no LMM farms with ditches in the Loess Region.

The highest median concentration of phosphorus was measured in Sand-250. In this region, the phosphorus concentration measured on 50% of the farms was higher than 0.15 mg P/l (see Table 3.15).

Table 3.13 Phosphorus concentrations[1,2] (in mg P/l) in ditch water in the winter of 2018-2019 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Reference	Sand-250	Sand-230	Loess[3]	Clay	Peat
Number of farms	11	20	-	49	51
First quartile (25th percentile)	<DT	<DT	-	<DT	<DT
Median (50th percentile)	0.15	<dt	-	0.087	0.067
Third quartile (75th percentile)	0.23	0.16	-	0.25	0.13

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT. [2] Phosphorus was measured as total dissolved phosphorus. [3] There are no LMM farms with ditches in the Loess Region.

3.2.3 *Comparison of the final figures with the provisional figures for 2019*

The figures presented in this section hardly deviate from the provisional figures reported by Lukács *et al*. (2020). The minor differences are mainly caused by a number of farms having 'dropped out' because they did not make use of the derogation or were not granted derogation, or because the farms were replaced in the derogation monitoring network.

3.2.4 *Provisional figures for measurement year 2020*

At the time of writing, provisional results were available for 2020, with the exception of the Loess Region for which no results were yet available. The results are 'provisional' because it is unknown at this time which farms will be actually granted derogation for measurement year 2020. This could mean that some concentration data might be changed in the final reporting of the figures of 2020, which will be published in 2022.

In 2020, decreases as well as increases were observed in various regions in the nitrate concentrations of the leachates. In Sand-230, the nitrate concentration increased from 47 mg/l to 64 mg/l in 2020 (see Table 3.8 and Table 3.16). In Sand-250, the average concentration in 2020 was only slightly higher than in 2019, namely 26 mg/l compared to 23 mg/l. In Sand-230, 42% of the farms had concentrations lower than 50 mg/l; in Sand-250, that percentage was 87% (see Table 3.16).

The nitrate concentrations decreased in the Clay and Peat regions. The average nitrate concentration in the Clay Region in 2020 was 37 mg/l compared to 44 mg/l in 2019. Of the farms in the Clay Region, 74% had nitrate concentrations below 50 mg/l in 2020 (see Table 3.16). The average nitrate concentration on farms in the Peat Region was 12 mg/l, which was lower than the value of 16 mg/l observed in 2019. In the Peat Region, 93% of the farms had a nitrate concentration below 50 mg/l.

2018 and 2019 were relatively dry years in the Netherlands. 2018 was a very dry year in all of the Netherlands, whereas in 2019 it was primarily the South and East of the country that experienced the droughts. Droughts can have an impact on the leaching of nutrients in various ways. This is discussed in more detail in section 4.2.3.

Table 3.14 Frequency distribution (%) of farm-specific average nitrate concentrations (in mg/l) in water leaching from the root zone on farms participating in the derogation monitoring network per region in 2020, expressed as percentages per class and average nitrate concentration per region

Concentration class nitrate (mg/l)	**Sand-250**	**Sand-230**	**Loess [1]**	**Clay**	**Peat**
Number of farms	46	113	-	57	57
Average concentration	26	64	-	37	12
< 15	37	7.1	-	32	75
15-25	11	9.7	-	16	5.3
25-40	35	15	-	19	8.8
40-50	4.3	11	-	7.0	3.5
> 50	13	58	-	26	7.0

[1] Results from the Loess Region were not yet available at the time the present report was being prepared.

In 2020, the nitrate concentrations in ditch water decreased in all the regions. In the Peat Region and in Sand-250, they decreased by almost half, whereas the decrease in Sand-230 and the Clay Region was somewhat less striking. In 2020, the average ditch water nitrate concentration in the Clay Region and the Peat Region amounted to 14 mg/l and 6.3 mg/l, respectively (see Table 3.17). The average nitrate concentration was 55 mg/l in the Sand-230 sub-region and 17 mg/l in the Sand-250 sub-region.

Table 3.15 Frequency distribution (%) of average ditch water nitrate concentrations (in mg/l) per farm, on farms participating in the derogation monitoring network per region in the winter of 2019-2020, expressed as percentages per class and average nitrate concentrations per region

Concentration class nitrate (mg/l)	**Sand-250**	**Sand-230**	**Loess ***	**Clay**	**Peat**
Number of farms	12	20	-	56	57
Average concentration	17	55	-	14	6.3
<15	50	10	-	66	95
15-25	25	15	-	21	0
25-40	17	30	-	7.1	1.8
40-50	8.3	5.0	-	0	0
>50	0	40	-	5.4	3.5

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

The nitrogen concentration in the water leaching from the root zone was also the highest in Sand-230 (see Table 3.18). The average nitrate concentrations in Sand-250 and The Clay and Peat regions do not differ much and are all near 10 mg/l. In 2019, the nitrogen concentration was higher in the Clay Region than in the Peat Region.

Table 3.16 Nitrogen concentrations[1] (in mg N/l) in water leaching from the root zone, measured in 2020 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)

Reference	Sand-250	Sand-230	Loess[2]	Clay	Peat
Number of farms	46	113	-	57	57
Average	9.3	18	-	10	9.8
First quartile (25th percentile)	6.1	10	-	4.6	7.3
Median (50th percentile)	9.1	15	-	7.6	8.8
Third quartile (75th percentile)	11	22	-	13	11

[1]Nitrogen was measured as total dissolved nitrogen. [2] Results from the Loess Region were not yet available at the time the present report was being prepared.

The nitrogen concentration in ditch water was also the highest in Sand-230 (see Table 3.19). A decrease was observed in all the regions in comparison to the 2018-2019 measurement year.

Table 3.17 Ditch water nitrogen concentrations[1] (in mg N/l) measured in the winter of 2019-2020 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Reference	Sand-250	Sand-230	Loess[2]	Clay	Peat
Number of farms	12	20	-	56	57
Average	7.0	15	-	5.0	5.2
First quartile (25th percentile)	4.6	8.2	-	3.0	3.8
Median (50th percentile)	6.2	12	-	4.0	4.7
Third quartile (75th percentile)	7.9	21	-	6.0	6.1

[1] Nitrogen was measured as total dissolved nitrogen. [2] There are no LMM farms with ditches in the Loess Region.

The phosphorus concentrations in the water leaching from the root zone were the highest in the Peat Region and the lowest in Sand-230 (see Table 3.20). In the 2019-2020 winter, the phosphorus concentrations in ditch water were the highest in Sand-250 but did not differ all that much from the concentrations in the other regions (see Table 3.21).

Table 3.18 Phosphorus concentrations[1,2] (in mg P/l) in water leaching from the root zone, measured in 2020 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)

Reference	Sand-250	Sand-230	Loess[3]	Clay	Peat
Number of farms	46	113	-	57	57
Average	0.19	0.11	-	0.2	0.38
First quartile (25th percentile)	<DT	<DT	-	0.065	0.12
Median (50th percentile)	<DT	<DT	-	0.16	0.26
Third quartile (75th percentile)	0.12	0.11	-	0.31	0.44

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.
[2] Phosphorus was measured as total dissolved phosphorus. [3] Results from the Loess Region were not yet available at the time the present report was being prepared.

Table 3.19 Phosphorus concentrations[1,2] (in mg P/l) in ditch water measured in the winter of 2019-2020 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)

Reference	Sand-250	Sand-230	Loess[3]	Clay	Peat
Number of farms	12	20	-	56	57
Average	0.25	0.22	-	0.24	0.2
First quartile (25th percentile)	<DT	<DT	-	<DT	0.08
Median (50th percentile)	0.16	<dt	-	0.12	0.14
Third quartile (75th percentile)	0.35	0.24	-	0.4	0.29

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT. [2] Phosphorus was measured as total dissolved phosphorus. [3] There are no LMM farms with ditches in the Loess Region.

4 Developments in monitoring results

4.1 Developments in agricultural practices

4.1.1 Developments in farm characteristics[1]

The quantity of milk (FPCM, Fat and Protein Corrected Milk) produced per farm increased during the 2006-2019 period by an average of over 4% per year (see Figure 4.1). The milk production per hectare increased over the period from 2006 up to and including 2016, after which it stabilised at a level of approximately 17,700 kg/ha. The milk production per cow increased rapidly, in particular after 2016, which can be attributed to regulations concerning phosphorus. Over the period from 2006 up to and including 2012, the percentage of farms with intensive livestock (such as pigs and poultry) decreased rapidly from 14% to a bit more than 5%, after which it stabilised at around 5% (see Figure 4.2).

The 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, 2000) (1 LSU = standard phosphate production from 1 dairy cow). The use of LSUs enables the aggregation of all animals present on a farm (dairy cows, young livestock, pigs, chickens, sheep, etc.). The livestock density in phosphate livestock units per hectare varies over the years with peaks in 2010 and 2016 of about 2.65 phosphate livestock units per hectare. After 2015, a gradual decrease took place to a density of 2.42 phosphate livestock units per hectare in 2019 (see Figure 4.2).

Phosphate production by intensive livestock declined over the period up to and including 2012 due to the decreasing number of farms with intensive livestock. However, this effect was largely compensated by the increase in the number of dairy cows per farm in the dairy farming sector. This trend points to a steady increase in scale and specialisation in the dairy farming sector, as well as intensification resulting in higher milk production per hectare of fodder crop (see Appendix 4, Table B4.1).

[1] This section only concerns dairy farms participating in the derogation monitoring network; other grassland farms have not been taken into consideration

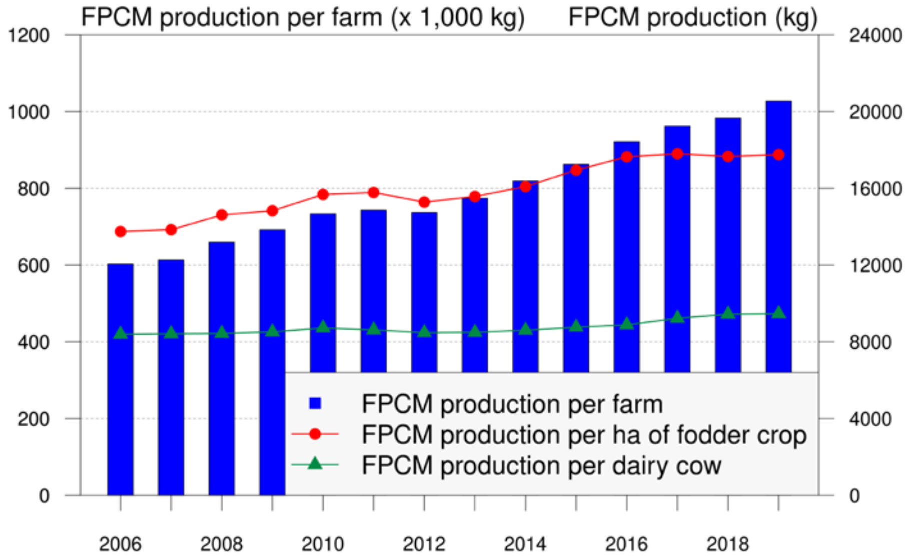

Figure 4.1 Average milk production per farm (1000 kg FPCM/farm) (left y-axis) and per hectare of fodder crop (kg FPCM/ha) and per cow (kg FPCM/cow) (both on right y-axis) on farms in the derogation monitoring network during the 2006-2019 period, expressed in FPCM (Fat and Protein Corrected Milk)

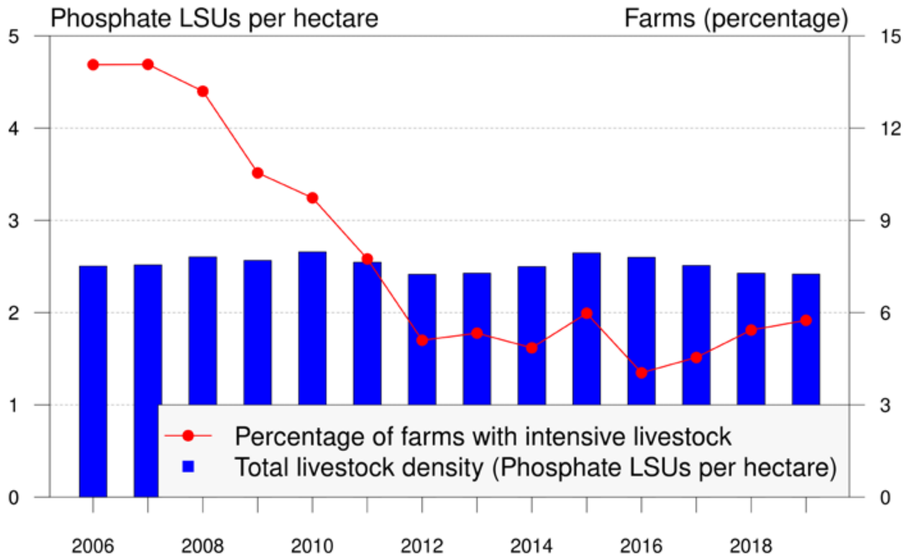

Figure 4.2 Average livestock density expressed in Phosphate Livestock Units per hectare on farms in the derogation monitoring network, and percentage of dairy farms with intensive livestock (e.g. pigs and chickens) in the 2006-2019 period

The proportion of farms with grazing in the derogation monitoring network increased once again in 2019 (see Figure 4.3; Appendix 4, Table B4.1). Over the period from 2006 up to and including 2015, the percentage of dairy farms with grazing decreased from 89% to 79%. After that, the number of derogation farms with grazing again increased gradually to 88% in 2019.

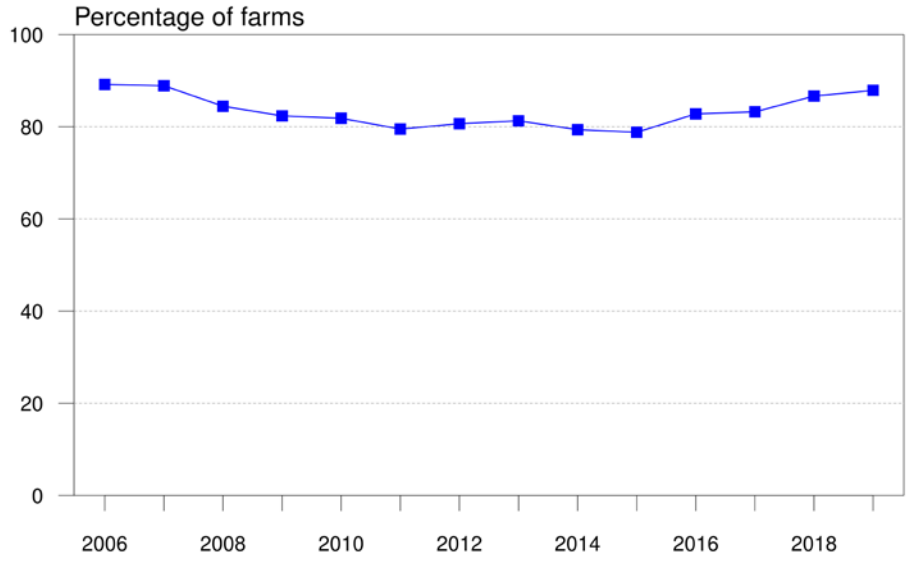

Figure 4.3 Percentage of dairy farms in the derogation monitoring network where cows are grazed in the 2006-2019 period

4.1.2 *Use of livestock manure*

Between 2006 and 2019, the average use of nitrogen in the form of livestock manure ranged from 230 kg to 246 kg of nitrogen per hectare. In 2019, 245 kg of nitrogen in the form of livestock manure was used per hectare (see Figure 4.4; Appendix 4, Table B4.2). In 2019, the average use of phosphate in the form of livestock manure was 72 kg per hectare. This further extends the practically uninterrupted decreasing trend during the period studied (see Appendix 4, Table B4.4).

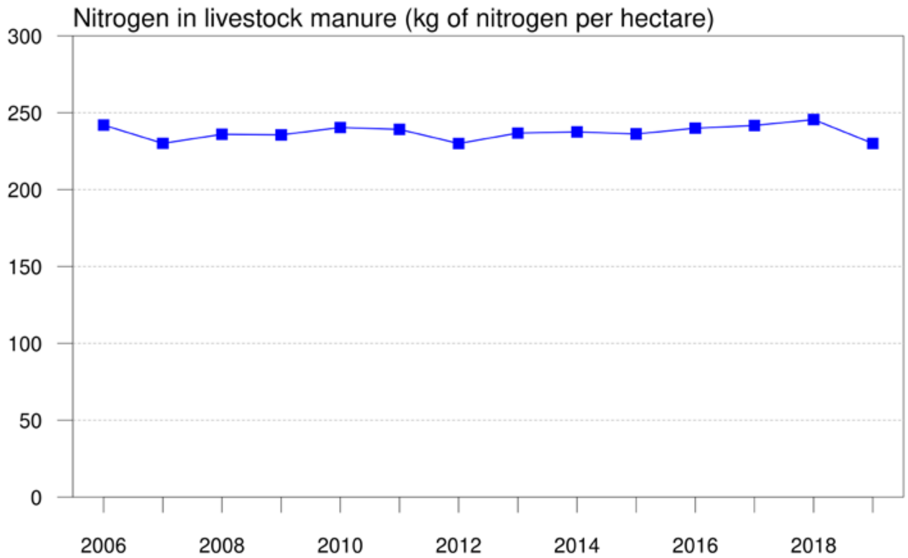

Figure 4.4 Nitrogen use in livestock manure (kg N/ha) on farms participating in the derogation monitoring network during the 2006-2019 period.

4.1.3 *Use of fertilisers compared to application standards*

The total use of plant-available nitrogen per hectare was lower in 2019 than in the previous five years. The use of plant-available nitrogen via livestock manure as well as via inorganic fertilisers was lower in 2019 than the average figure for previous years (see Appendix 4, Table B4.3).

The nitrogen application standard per hectare in 2019 was 279 kg/ha. The difference (underutilisation) between the actual nitrogen usage and the nitrogen application standard decreased significantly, particularly in the 2006-2009 period (see Figure 4.5). In 2006 and 2007, the difference between actual usage and the application standard for plant-available nitrogen amounted to almost 66 kg N per hectare, whereas from 2010 up to and including 2017 this difference varied between 20 and 29 kg per hectare. In 2018 and 2019, this difference again increased to 36 and 43 kg/ha, respectively.

It is worth noting that, since 2014, the average nitrogen application standard on derogation farms has been somewhat higher than in the previous five years. The most important factor in this regard was the higher proportion of grassland, which is subject to a higher application standard than silage maize. The proportion of grassland was roughly 84% between 2006 and 2013 and, as a result of the stricter derogation conditions, this increased to almost 88% between 2014 and 2019 (see Appendix 4, Table B4.1).

The use of inorganic nitrogen-containing fertilisers remained fairly stable during the 2006-2017 period at an average of 132 kg/ha, but decreased to 122 and 126 kg/ha in 2018 and 2019, respectively (see Appendix 4, Table B4.3).

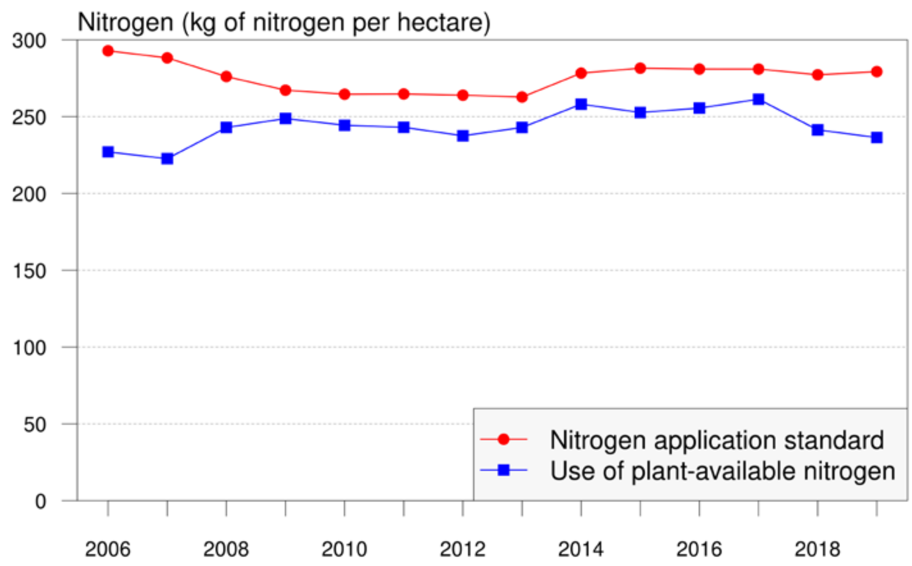

Figure 4.5 Use of plant-available nitrogen in livestock manure and inorganic fertilisers (kgN/ha) and total nitrogen application standard (kg N/ha) on farms in the derogation monitoring network during the 2006-2019

Since 2006, the phosphorus application standards have been gradually reduced from 108 to 84 kg P/ha. The use of phosphate fertilisers decreased from an average of 100 to 73 kg/ha in 2019 (see Figure 4.6 and Appendix 4, Table B4.4).

During the period from 2006 up to and including 2009, this decrease was due primarily to the reduced use of inorganic phosphate fertilisers. During the period from 2010 to 2014, the use of phosphate from inorganic fertilisers remained constant, and the decrease was due primarily to the reduced use of phosphate from livestock manure (see Appendix 4, Table B4.4). Since 2014, the use of phosphate from inorganic fertilisers has no longer been permitted on derogation farms. Nevertheless, the decreasing trend in the use of phosphate from livestock manure continued. This can be attributed to the combination of a higher nitrogen/phosphate ratio in the fertiliser and the maximum allowable application of nitrogen from livestock manure. As a result, the nitrogen application standard became an increasingly important determining factor for the use of livestock manure.

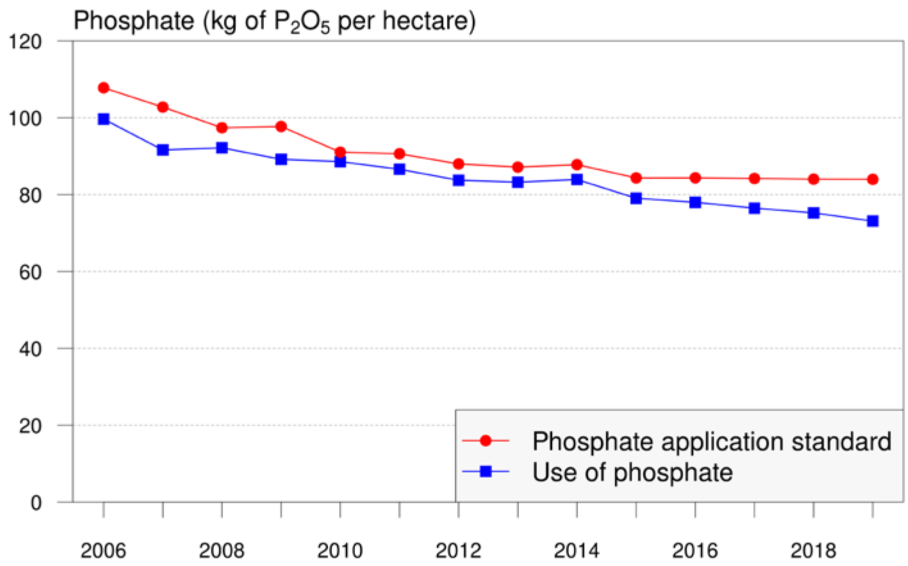

Figure 4.6 The use of phosphate via livestock manure and inorganic fertiliser (kg P_2O_5/ha) and the total phosphate application standard (kg P_2O_5/ha) on farms in the derogation monitoring network during the 2006-2019 period

4.1.4 Crop yields

In 2019, the yield of grass increased to 9700 kg of dry matter per hectare in comparison to the very dry 2018 year (8300 kg of dry matter per hectare). However, the yield of grass in 2019 was still somewhat lower than the average figure over the period from 2006 up to and including 2018, which was 10,300 kg of dry matter per hectare. 2019 was also a relatively dry year, in particular in the South and East of the country (see Figure 4.7; Appendix 4, Table B4.5). The average yield of silage maize also increased again in 2019 to 17,000 kg of dry matter per hectare, which is equal to the long-term average (2006 up to and including 2018) of 16,800 kg. The nitrogen and phosphorus yields for both crops also increased again in 2019 in comparison to 2018 (see Figure 4.8 and Figure 4.9; Appendix 4, Table B4.5).

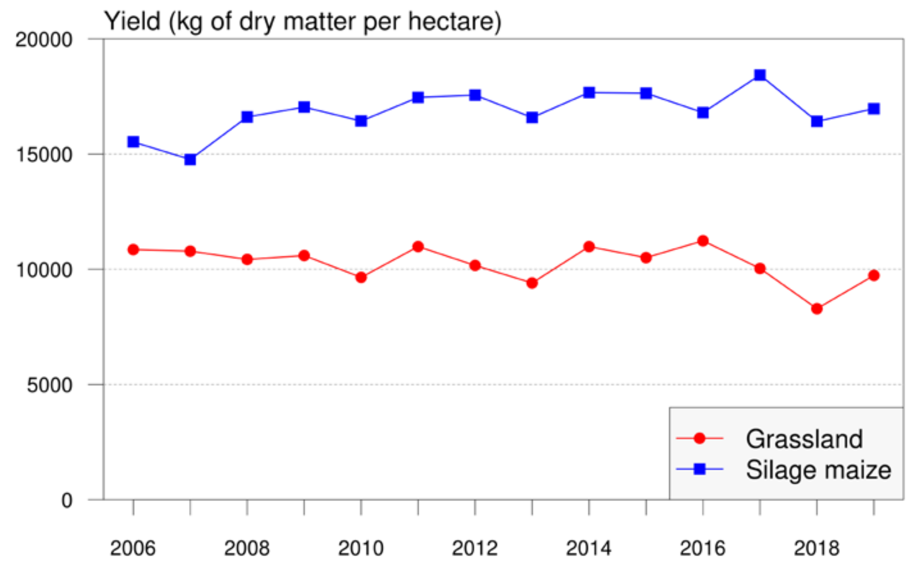

Figure 4.7 Average dry-matter yields (kg of dry matter per hectare) for grassland and silage maize on farms in the derogation monitoring network during the 2006-2019 period

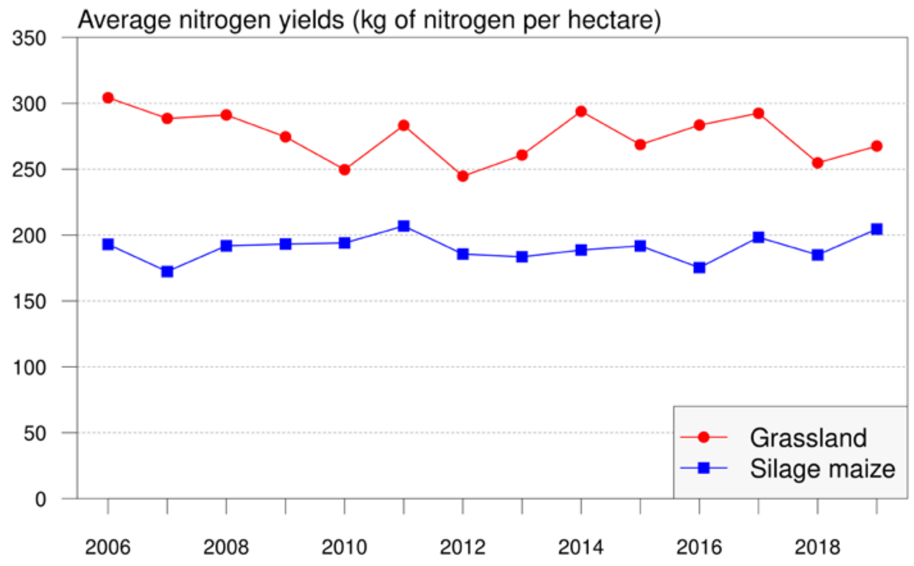

Figure 4.8 Average nitrogen yields (kg N/ha) for grassland and silage maize on derogation farms during the 2006-2019 period

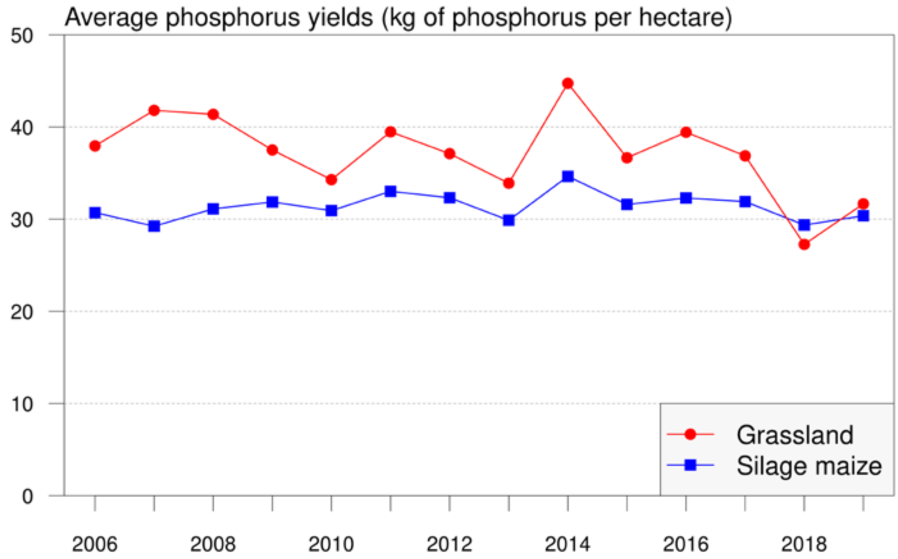

Figure 4.9 Average phosphorus yields (kg P/ha; 1 kg of phosphorus = 2.29 kg of P_2O_5) for grassland and silage maize on derogation farms during the 2006-2019 period

4.1.5 *Nutrient surpluses on the soil surface balance*

In 2019, the average nitrogen surplus on the soil surface balance was 156 kg of nitrogen per hectare, which was less than the surplus measured for any of the years from 2006 up to and including 2018. The nitrogen surplus on the soil surface balance in 2019 is therefore 24 kg per hectare less than the average surplus over the 2006-2018 period. Overall, during the period from 2006 up to and including 2019, the surplus decreased significantly. The decrease in the nitrogen surplus on the soil surface balance in 2019 compared to previous years can be attributed primarily to the reduced input of nitrogen from sources such as organic fertilisers and feed (see Figure 4.10; Appendix 4, Table B4.6).

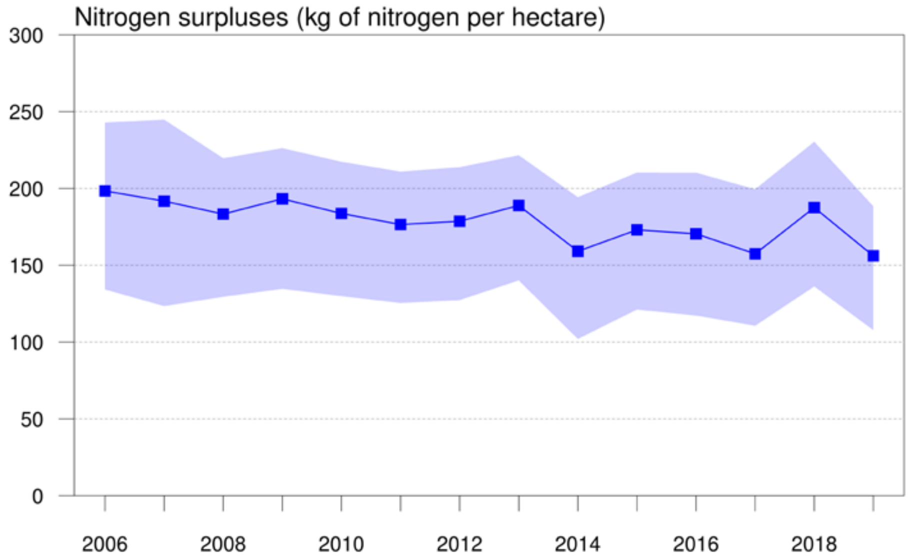

Figure 4.10 Average nitrogen surpluses on the soil surface balance (kg N/ha) on farms in the derogation monitoring network, and the nitrogen surpluses on the 25% of farms with the lowest surpluses (first quartile or 25th percentile), and nitrogen surpluses on the 25% of derogation farms with the highest surpluses (third quartile or 75th percentile) during the 2006-2019

As is the case for the farms in all the soil type regions of the entire derogation monitoring network, the nitrogen surplus on the soil surface balance in all the separate soil type regions also decreased in 2019 in comparison to 2018. The nitrogen surplus on the soil surface balance is consistently higher in the Peat Region than in the other regions (see Figure 4.11). This is mainly due to additional mineralisation on peat soils, which has been estimated and included on the input side of the balance sheet (see Appendix 2, Table B2.3). Over the longer term, four of the five soil type regions differentiated show a decreasing trend with respect to the nitrogen soil surplus. The only exception in this regard is the Loess Region (see Figure 4.11; see Appendix 4, Table B4.7).

In 2016 (Lukács et al., 2016), the first derogation report was published that drew a distinction between the Sand-250 and Sand-230 sub-regions. Figure 4.11 shows that the average nitrogen surplus in both sub-regions is nearly the same in many years, despite differences in farm characteristics.

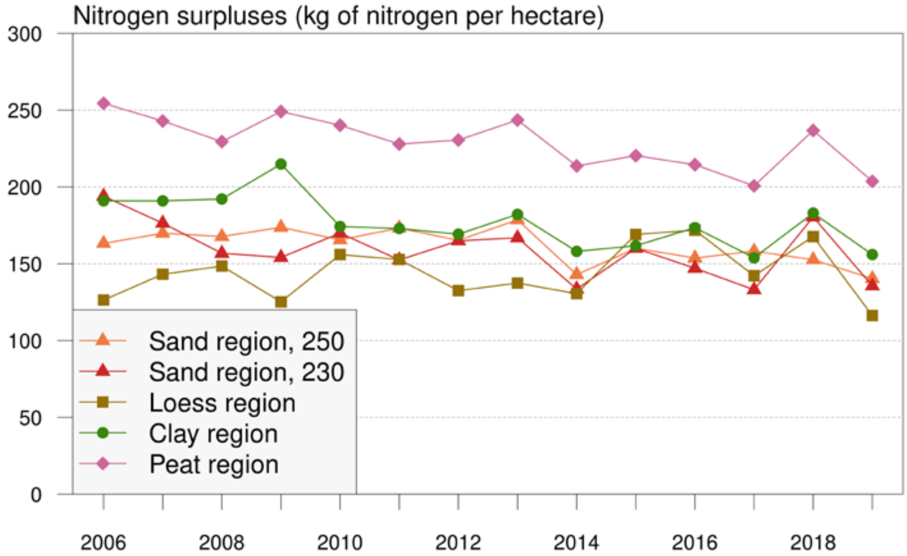

Figure 4.11 Average nitrogen surpluses per region (kg N/ha) on derogation farms in the 2006-2019 period

In 2019, the average phosphate surplus on the soil surface balance was 4 kg of phosphate per hectare, which marked a decrease in comparison to the 16 kg per hectare measured in 2018. In 2018, the phosphate surplus was relatively high as a result of dry weather conditions. During the 2006-2018 period, there was an average positive surplus of 11 kg phosphate/ha (see Figure 4.12; Appendix 4, Table B4.8). The significant decrease in the phosphate surplus over the entire 2006-2019 period was primarily due to a reduced use of phosphate fertilisers and an increasing trend in the output of phosphate (see Appendix 4, Table B4.4 and B4.8).

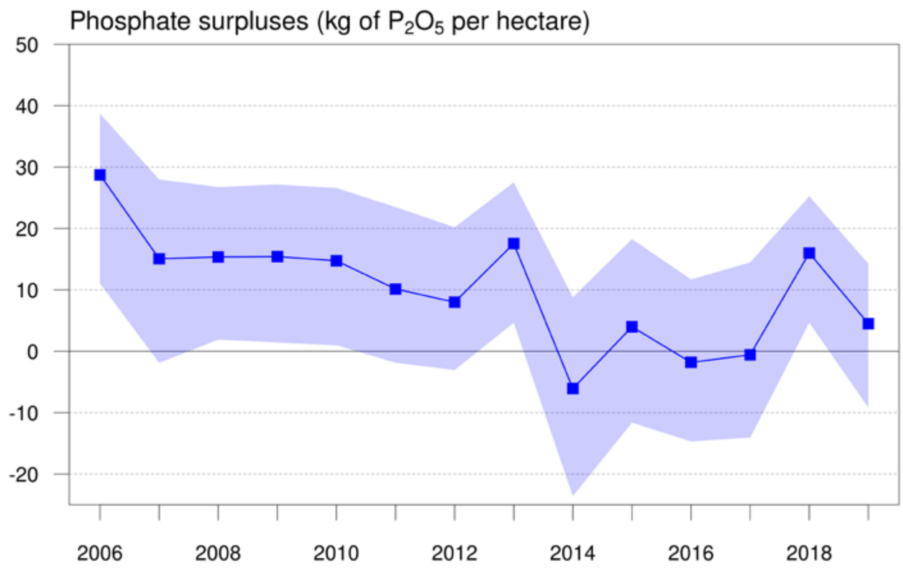

Figure 4.12 Average phosphate surpluses (kg P_2O_5/ha) on farms in the derogation monitoring network, and the phosphate surpluses on the 25% of farms with the lowest surpluses (first quartile or 25th percentile), and phosphate surpluses on the 25% of derogation farms with the highest surpluses (third quartile or 75th percentile) during the 2006-2019 period

4.2 Development of water quality

4.2.1 Development of average concentrations during the 2007-2020 period

Up to and including 2017, there was a clear downward trend in the average nitrate concentrations in all regions, with the exception of the Peat Region where the average nitrate concentration had always been low.

In 2018, the nitrate concentrations in the Loess Region and in Sand-230 increased (see Figure 4.13). In 2019, the nitrate concentrations continued to increase in all regions, with the exception of the Loess Region, probably due to the drought experienced in 2018 (see section 4.2.3). In 2020, the nitrate concentrations decreased in the Clay and Peat regions. In the Sand-250 and Sand-230 subregions, the concentrations increased further.

In the Clay Region as well as in Sand-230, the nitrate concentrations in 2020 were higher than the average values measured over the entire measurement period (see Appendix 4, Table B4.9). Although the concentration in the Clay Region decreased in 2020 compared to 2019, it was therefore still higher than in previous years. These increased values are most likely due to the droughts occurring in previous years (see section 4.2.3).

The Peat Region and Sand-230 do not show any divergences from the average values over the 2007-2019 measurement period (see Appendix 4, Table B4.9). In 2019, the nitrate concentration in the Loess Region decreased to 59 mg/l compared to the 65 mg/l measured in 2018.

In 2020, the average concentration in Sand-230 exceeded the standard of 50 mg/l. In the other regions, the average concentration remained below the standard. In spite of the increases in Sand-230 and Sand-250, there is still a statistically significant downward trend in these areas over the entire measurement period. There is no trend visible in the Peat Region and Loess Region (see Appendix 4 Table B4.9). As a result of the past two dry years, there is an increasing trend over the entire measurement period in the Clay Region.

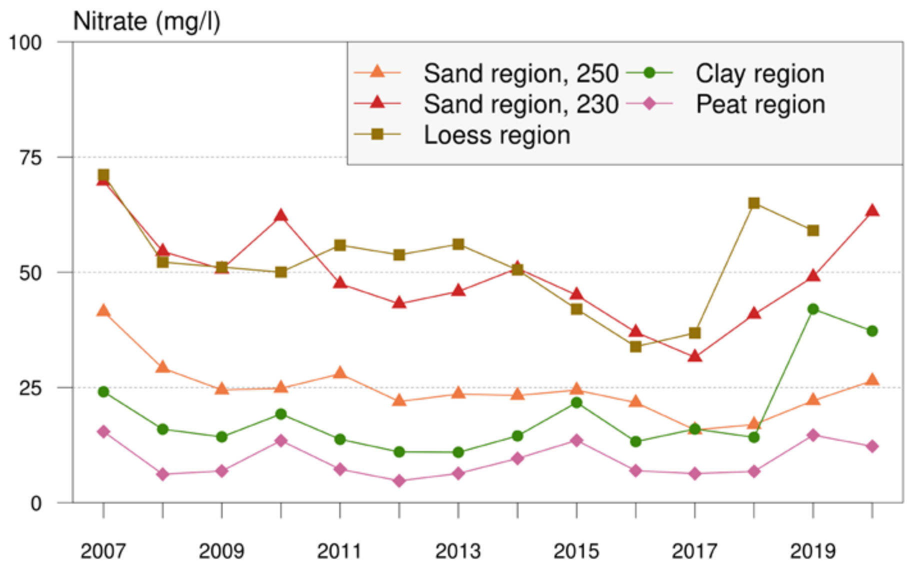

Figure 4.13 Average nitrate concentration (mg/l) in water leaching from the root zone on derogation farms in the four regions during the 2007-2020 period

The trend for the number of farms with a nitrate concentration higher than the standard of 50 mg/l shows a similar picture as can be seen for the nitrate in water leaching from the root zone. After a marked decrease until 2017, the number has increased since 2018 (see Figure 4.14). In 2020, the number decreases again in the Clay Region and the Peat Region, whereas it continues to increase in Sand-250 and Sand-230. In Sand-250 and the Peat Region, approximately 90% of the farms had an average nitrate concentration below the standard in 2020. The corresponding figure in Sand-230 was a bit over 40% of the farms, and in the Clay Region, approximately 75% of the farms had an average nitrogen concentration below 50 mg/l. In the Loess Region, this was the case for 40% of the farms in 2019.

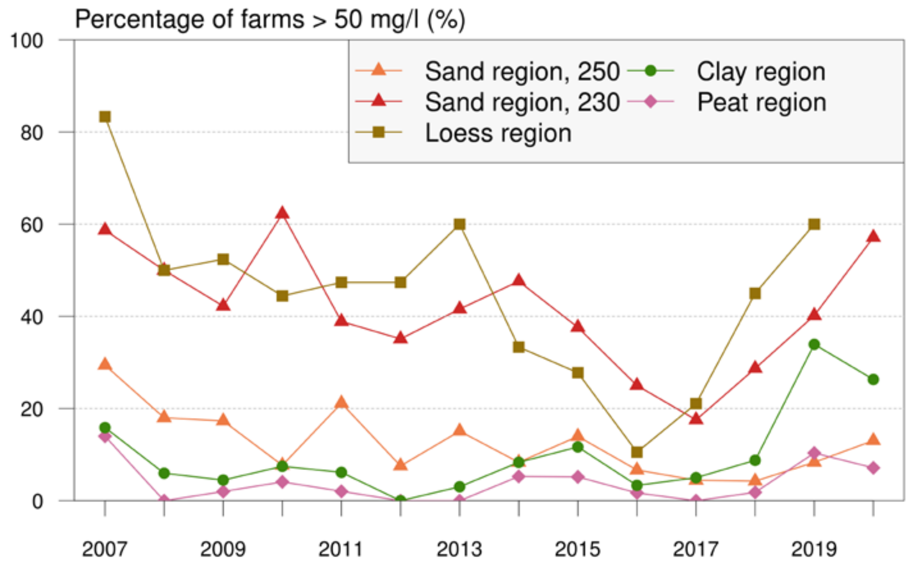

Figure 4.14 Percentage of derogation farms with an average nitrate concentration in the water leaching from the root zone higher than 50 mg/l during the 2007-2020 period

In 2020, the nitrate concentration in ditch water decreased in all regions (see Figure 4.15). Nevertheless, the average concentration in Sand-230 was still much higher than in previous years. In the Clay Region, it was also higher than the average value in previous years (see Appendix 4, Table B4.10). In the Peat Region and Sand-250, the average did not differ from the value measured in previous years.

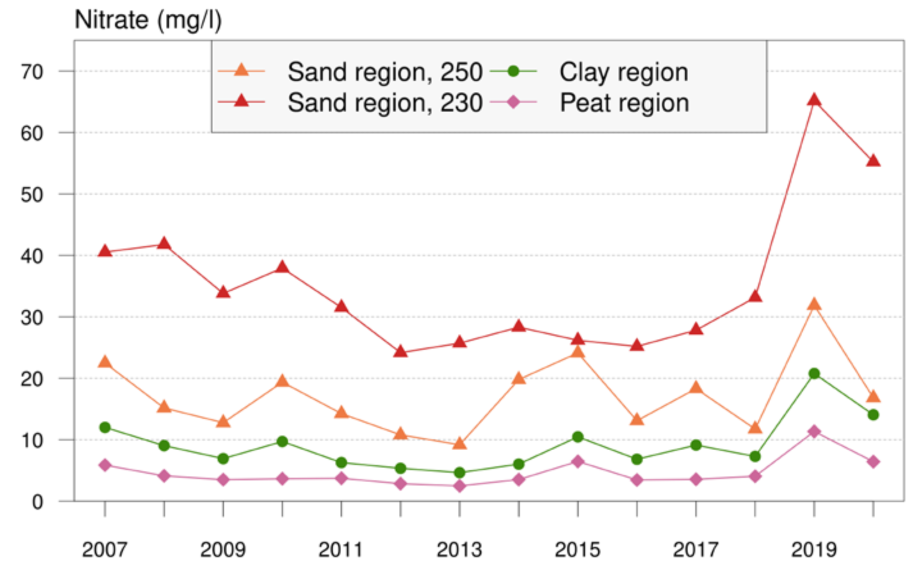

Figure 4.15 Average ditch water nitrate concentrations (mg/l) on derogation farms in the three regions during the 2007-2020 period

In 2020, the phosphorus concentration in the water leaching from the root zone was similar to the value measured in the previous years. In the Clay and Peat regions, a downward trend is visible during the measurement period (see Appendix 4, Table B4.9). The phosphorus concentration remained stable in the other regions. The phosphorus concentration in the ditch water in the Sand Region remained practically unchanged. After a slight decrease in 2019, the phosphorus concentrations in ditch water in the Peat and Clay regions were at practically the same level as the average value measured in previous years (see appendix 4, B4.10).

The nitrogen concentration in the water leaching from the root zone in the Sand Region and the Loess Region decreased during the measurement period. As was the case for the nitrate concentration, an increasing trend can be seen in the Clay Region. No trend is visible in the changes in nitrate concentration in the Peat Region. In 2020, the nitrate concentration in ditch water in all the regions, with the exception of Sand-250, showed an increase in comparison to the average value measured over the entire measurement period (see Appendix 4, Table B4.9 and B4.10).

4.2.2 Effects of environmental factors and sample composition on nitrate concentrations

A statistical method has been developed for the Sand Region in order to correct the measured nitrate concentrations for the effects of weather conditions such as the droughts of past years, groundwater levels and changes in the composition of the sample (see chapter 2.4 and Boumans and Fraters, 2011). This method does not take all the processes into consideration that have an influence on the nitrate concentration, and is based on correlations. For example, the method does not take the crop yield and the nitrogen soil surplus into account.

This method was used to correct the nitrate concentrations in the Sand and Clay regions (see Figure 4.16). The standardised concentrations are presented only in this section and in tables B4.11, B4.12 and B4.13. All other concentrations are measured values. The standardised nitrate concentrations in Sand-250 in 2019 and 2020 do not differ significantly from those in previous years (see Table B4.11). In 2020, the standardised concentration in Sand-230 showed an increase (see Table B4.12). However, the concentration in 2019 does not differ significantly from the values during the 2011-2018 period. In the Clay Region, the highest standardised concentrations were those calculated for 2019 and 2020, which were higher than during the previous 2011-2018 period (see Table B4.13). However, the concentration in the Clay Region in 2020 does not differ significantly from the starting period of the derogation monitoring network (2006-2010). In 2019 and 2020, the standardised nitrate concentrations are lower than the measured concentrations in Sand-230 and the Clay Region, the regions with the largest measured increase during the years in question. These differences support the argument that the droughts of past years can have an effect on the measured nitrate concentrations over a period of several years.

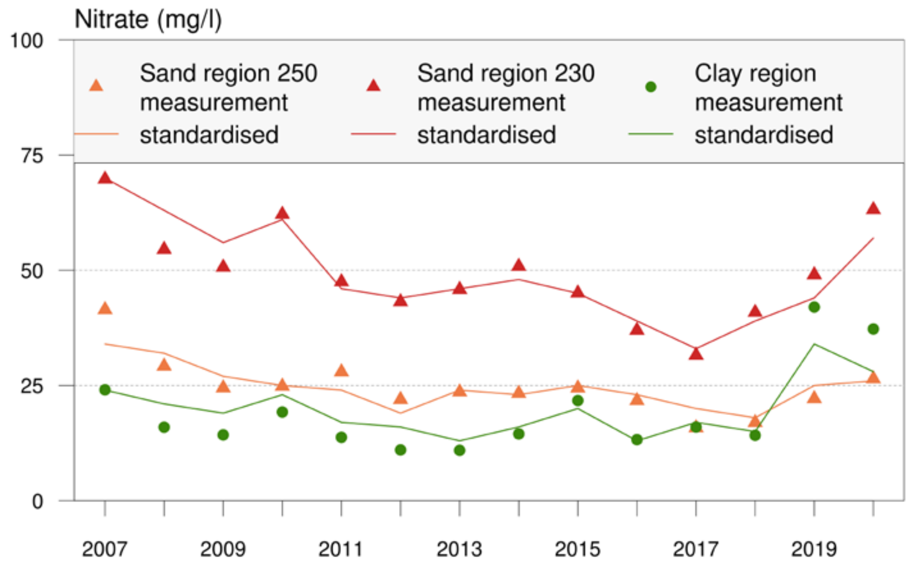

Figure 4.16 Nitrate concentrations (mg/l) in water over time in water leaching from the root zone on farms in the derogation monitoring network in Sand-250, Sand-230, and the Clay Region in successive measurement years as well as the standardised nitrate concentrations.

4.2.3 *Increased nitrate concentrations due to the droughts in 2017, 2018, and 2019*

In 2019, there was a strong increase in the nitrate concentrations in all regions. This was probably due to the droughts occurring in previous years. The nitrate concentrations in 2020 were also higher than in previous years, but this was no longer true of all regions and water types (see section 4.2.1 and tables B4.9 and B4.10). This was probably due to the fact that the drought in 2018 affected all of the Netherlands, whereas there were large local differences in the degree of droughts in 2019. The precipitation deficit in the East and South of the Netherlands in 2019 was similar to that in 2018. However, the precipitation deficit in the West of the Netherlands was relatively small. In addition, other factors can also play a role such as the precipitation deficit during the growing season, the precipitation surplus during the winter season when water leaches out of the root zone, and potential delayed effects of nitrogen that has not yet leached out. In the Sand Region, where the groundwater levels are also measured when samples of groundwater are taken, we see that, in spite of a small rise in 2020, the groundwater levels are still much lower than in previous years (see Figure 4.17 and tables B4.11 and B4.12).

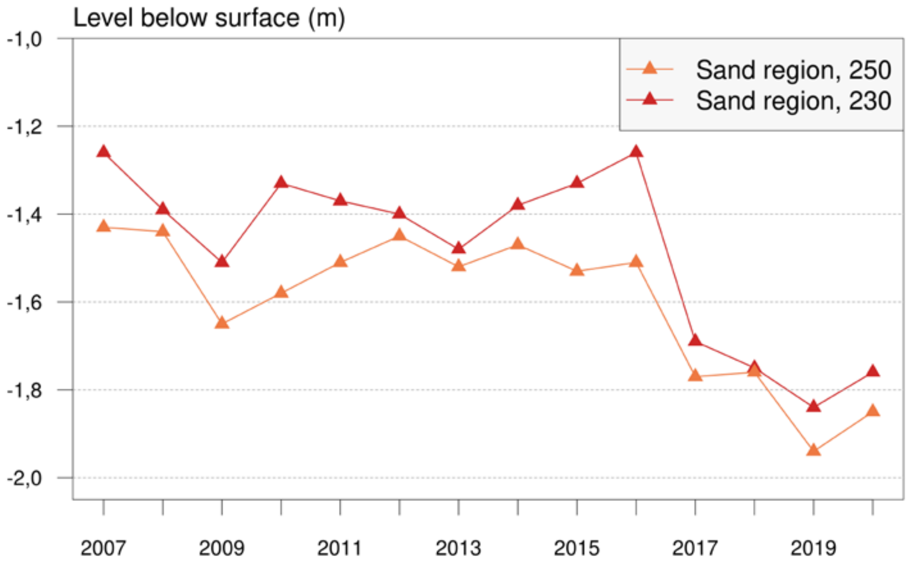

Figure 4.17 Average groundwater levels measured (in metres below ground level) on farms in the derogation monitoring network in Sand-250 and Sand-230

Drought can influence the nitrate concentrations in the leached water in various ways: Due to drought, crops grow less quickly, which in turn reduces the uptake of nitrogen by the crop and reduces the crop yields. The nitrogen soil surplus will increase as a result, which can lead to more leaching. In 2018, reduced crop yields and increased soil surpluses were in fact seen. In 2019, the crop yields increased again, and the soil surpluses decreased again, primarily due to a reduced input of nitrogen (see Figure 4.7 and Figure 4.11). In addition, due to the droughts, less nitrate will be broken down via denitrification so that more nitrate can leach into the groundwater and surface water. A so-called evaporation effect can also occur: if the soil becomes severely dehydrated, the soil moisture in which the nitrate is dissolved evaporates, which means that the concentration increases. During conditions of extreme droughts, these processes can take place simultaneously and have a cumulative effect on the nitrate concentrations.

The effect of droughts on the nitrate concentration in Sand-230 appears to be much greater than in Sand-250 (see Figure 4.13 and Figure 4.15). Although the groundwater levels in both areas have been greatly lowered since 2017 (see Figure 4.17), the increase in nitrate concentrations in Sand-230 was much greater than in Sand-250 in 2019 as well as 2020. The limited increase in nitrate concentrations in Sand-250 may possibly be due to the presence of wetland soils containing more organic matter on the farms in Sand-250. These soils can retain moisture more effectively than dry soils, enabling better crop growth and facilitating denitrification under anaerobic conditions. Sand-250 is the only area in which crop yields remained relatively stable in 2018 and the nitrogen soil surplus did not increase (see Figure 4.11 and Appendix 4, Table B4.7).

Strikingly, in Sand-230 as well as Sand-250, the average nitrate concentration in ditch water in 2019 (see Figure 4.15) showed a much greater increase than the concentration in the water leaching from the root zone (see Figure 4.13). This is probably due to the dry autumn in 2018 and the mild winter, which in turn resulted in a small precipitation surplus. It was probably possible for nitrate to leach into the ditch water, but the limited precipitation surplus meant that not much dilution took place. The high concentrations in the ditch water were probably caused by the combination of high nitrate concentrations in the soil moisture due to the dry summer and the limited dilution via the reduced precipitation surplus. In 2020, the nitrate concentrations in the ditch water decreased in Sand-230 as well as Sand-250. In spite of a wetter autumn and winter, the concentration in Sand-230 is still higher than the long-term average (see Appendix B4.10). This can be explained in part by the fact that in 2019 the South and East of the Netherlands recorded the least precipitation.

With regard to the water leaching from the root zone into the groundwater, the limited precipitation surplus during the 2018-2019 winter season was probably the reason why the concentrations in the water leaching from the root zone in 2019 did not increase as much as did the concentrations in the ditch water. On the other hand, the concentrations in the water leaching from the root zone react more slowly to external conditions so that effects are delayed and nitrate reaches the groundwater via leaching from the root zone only at a later time. The increased concentrations in 2020 in the water leaching from the root zone are possibly not only due to the drought in 2019 but also to the delayed effect of the increased nitrogen soil surplus in 2018.

During the summer period, the water leaching from the root zone in the Sand regions is sampled in the uppermost metre of the groundwater. The precipitation surplus from the previous winter season, together with the fertilisers leaching from the root zone, have by then entered the groundwater. Depending on the incoming precipitation surplus, the upper layer of groundwater consists roughly of a mixture of water that leached from the root zone during the previous winter period and older groundwater that, due to a longer stay in the phreatic layer, was more subject to denitrification.

Although strongly concentrated, the limited precipitation surplus during the 2018-2019 winter season replenished the groundwater to only a limited degree. As a result, the concentration in the uppermost metre of the groundwater in 2019 was influenced more heavily by older and more denitrified groundwater. In 2020, a further increase of the nitrate concentrations in the water leaching from the root zone in the Sand regions can be explained partly by the reduced influence of older groundwater (from before the droughts of 2018 and 2019). The droughts in 2018 and 2019 probably have a relatively greater influence on the groundwater quality in 2020.

In clay soils, in addition to the above processes, drought can lead to cracks forming in the soil, which in turn allows fertilisers leaching from the root zone to reach the groundwater more quickly. This probably explains the striking increase of nitrate concentration in the Clay Region in 2019. In addition, in this region, the water leaching from the root zone on farms with tile drainage is sampled via samples taken from the drain water instead of from the groundwater. This may also have contributed to the striking increase in concentration in the Clay Region compared to the Sand Region. Drain water reacts more quickly to changes in precipitation than does groundwater. For example, in 2019, the relative increase of nitrate concentration in drain water was greater than in groundwater. In 2020, the concentration in drain water went back down again, whereas it increased further in groundwater.

On the farms in the Loess Region, the strong increase of the nitrate concentration in the soil moisture in 2018 is possibly due to the higher nitrogen soil surpluses in 2015 and 2016 in combination with the effects of evaporation in 2018. In 2019, there is a slight decrease, which is possibly due to the lower nitrogen soil surplus in 2017. As soil moisture is sampled in the Loess Region, no mixing takes place here with older groundwater components.

4.3 Effects of agricultural practices on water quality

Nitrogen

Between 2006 and 2019, the average nitrogen soil surpluses over all the regions showed a statistically significant decreasing trend (see Figure 4.11 and Appendix 4, Table B4.6). The nitrate concentration decreased over the 2007-2020 period in Sand-230 as well as Sand-250, whereas there was no trend visible in the changes that took place in the Peat and Loess regions. Since this year, an increasing trend can be seen in the Clay Region (see Figure 4.13 and Appendix 4, Table B4.10).

The strong decrease in nitrate concentrations at the beginning of the measurement series was possibly due to changes in farming operations before the derogation monitoring network was set up. With the exception of Peat soils, the nitrogen soil surplus depends on the balance between the annual input and the annual degradation of organically bound nitrogen. With the exception of peat soils, nitrogen input from the soil is therefore not included in the soil surplus. After-effects can remain noticeable for up to four years (Verloop, 2013).

Over the 2014-2017 period, a second downward trend is visible in the nitrate concentrations, particularly in Sand-230 and the Loess Region, which is possibly due to the low nitrogen soil surplus in 2014. In 2016 and 2017, a slight decrease in nitrate concentrations is visible in Sand-250 (see Figure 4.11).

The increased nitrate concentrations in 2019 appear to be a logical consequence of the increased nitrogen soil surpluses measured in 2018 as a result of the poor growing season in 2018. The degree to which concentrations increased appears to be strongly influenced by the dry weather conditions in 2018. In 2020, the nitrate concentrations in the water leaching from the root zone in the Sand regions continued to increase, and they remained at an elevated level in the Clay Region in spite of the lower nitrogen soil surpluses in 2019. This is probably due to the fact that the increased nitrogen soil surpluses in 2018, resulting from the drought, continue to have an effect for more than one year.

There are additional aspects in the operations of the derogation farms that can influence the nitrate concentration but that hardly change the nitrogen soil surplus:

- Since 2014, the derogation farms are required to have a minimum percentage of 80% grassland; in the period before that, the minimum was 70%. This resulted in an increase in the acreage of grassland in 2014 and 2015. The increasing proportion of grassland could also lead to a decrease in the nitrate concentration. Denitrification in grassland is higher than in land used for maize crops due to the higher concentration of degradable organic matter. The leaching fraction (i.e. the percentage of the nitrogen soil surplus that leaches out) is much higher on land used to cultivate maize than on grassland (Fraters *et al*., 2007a and 2012). However, the effect of this on the water quality cannot be determined independently of all the other developments on the farms and in the soil.
- The assumption is that the decrease in grazing on derogation farms leads to lower nitrogen leaching. Although grazing is again on the increase in recent years, there is still a downward trend over the period from July up to and including October (Appendix 4, Table B 4.1). The nitrogen leaching that takes place during grazing in the second half of the growing season is relatively high, as the nitrogen in the urine released onto the surface cannot be completely absorbed by the grass (Corré *et al*., 2014). An increase in grazing during the period from May up to and including June does not therefore automatically result in a higher nitrogen leaching.
- The ploughing-up of grassland has decreased (Van Bruggen *et al.,* 2020), among other reasons because this practice is no longer permitted in autumn on sandy and loessial soils since the introduction of application standards in 2006. In addition, the EU’s agricultural policy as implemented in the Netherlands is also aimed at increasing the area of permanent grassland. This could result in lower nitrate concentrations in the uppermost groundwater. There are indications that the prohibition of ploughing-up grassland in the autumn has led to an increase in catch crops, often silage maize, on dairy farms. One can therefore not exclude the possibility that the targeted reduction of nitrate leaching by placing restrictions on the season when the ploughing of grassland is permitted has been less than intended due to the increase in other types of catch crops (Velthof *et al*., 2017).

Phosphate
The phosphate surplus on the soil surface balance displayed a downward trend during the entire measurement period (see Figure 4.12). The phosphorus concentrations in water leaching from the root zone in the Clay Region and Peat Region also displayed a downward trend (see Appendix 4, Table B4.9). This is in line with the expectation that a decrease in phosphate soil surpluses would lead to a decrease in phosphate concentration in the water leaching from the root zone.

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Websites

CBS, Landbouwtelling: http://statline.cbs.nl

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

B1.1 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 is part of the Minerals Policy Monitoring Programme (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 (the 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. In doing so, the proportion of the total surface area of cultivated land in a given stratum was taken into account (the greater the proportion of cultivated land in a stratum, the larger the number of farms to be included in the sample), as well as a minimum representation for each groundwater body.

The Companies Information Network (BIN) of Wageningen Economic Research was established primarily for the national sample of the Dutch part of the *Farm Accountancy Data Network* of the European Commission (FADN). For specific purposes such as the LMM, extra farms are selected and recruited and added to the BIN insofar as is necessary.

The recruitment of farms for the derogation monitoring network was initially targeted at farms participating in the Farm Accountancy Data Network (FADN; reporting 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 required 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 included all farms that registered for derogation in 2006. Sixteen of the additional participants thus selected also participated in the 'Koeien & Kansen' (K&K: Cows and Opportunities) research project (see www.koeienenkansen.nl).

Replacements for farms that dropped out during the 2006-2019 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.

B1.2 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, 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 60% of the total area of cultivated land were included in the selection for derogation monitoring purposes. We have opted for a selection requirement that falls short of the 70% minimum prescribed by law (80% as of 2014) because the Netherlands Enterprise Agency (RVO.nl) and Wageningen Economic Research use different operational methods and definitions when registering farm data. Due to these discrepancies, the FADN grassland percentages may differ from the data registered by the Netherlands Enterprise Agency. In addition, farmers may adjust the grassland percentage on their farms from year to year, so that the percentage may exceed the required 70% or 80% in a later year.

The consequences of these selection criteria are illustrated in Tables B1.1 and B1.2. Table B1.1 (farms) and Table B1.2 (acreages) specify how the sample population has been derived from the 2019 Agricultural Census data and a database maintained by the Netherlands Enterprise Agency. This database contains over 17,800 so-called ‘BRS numbers’ of farms that registered for derogation for 2019. BRS numbers are the registration numbers of farms registered with the Netherlands Enterprise Agency. As 452 BRS numbers did not appear in the 2019 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 more than 17,300 farms for which data were available in the 2019 Agricultural Census.

Table B 1.1 Proportion of dairy and other grassland farms (%) represented in the sample population of the derogation monitoring network in 2019

	Distribution of farms		
	Dairy farms	**Other grassland farms**	**Total**
All farms registered for derogation in 2019	75	25	100
Farms smaller than 25,000 SO units	0.0	7.4	7.4
Organic farms	0.2	0.2	0.5
Farms smaller than 10 hectares	0.6	1.8	2.4
Farms where grassland makes up less than 60% of cultivated land	0.1	0.1	0.2
Sample population	74	16	90

Source: Statistics Netherlands Agricultural Census 2019, data processed by Wageningen Economic Research

Table B 1.2 Proportion of cultivated land (%) on dairy and other grassland farms represented in the sample population of the derogation monitoring network in 2019

	Distribution of acreage of cultivated land		
	Dairy farms	**Other grassland farms**	**Total**
All farms registered for derogation in 2019	89	11	100
Farms smaller than 25,000 SO units	0.0	1.2	1.2
Organic farms	0.3	0.1	0.4
Farms smaller than 10 hectares	0.1	0.3	0.4
Farms where grassland makes up less than 60% of cultivated land	0.1	0.1	0.2
Sample population	88	9.5	98

Source: Statistics Netherlands Agricultural Census 2019, data processed by Wageningen Economic Research

Tables B1.1 and B1.2 show that specialised dairy farms account for 75% of all farms that registered for the 2019 derogation scheme, and account for 89% of the total acreage of cultivated land. Almost all dairy farms also met 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 (Standard Output) units and a small area of cultivated land. Under the adopted selection criteria, 10% of all farms registered for derogation are excluded from the sample population. However, these farms account for no more than 2% of the total acreage for which farmers have requested derogation.

B1.3 Explanation of 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. With effect from 2012, stratification based on groundwater body was replaced by stratification based on district. These stratification variables are explained below.

B1.4 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 (NGE) (Van der Veen *et al*., 2012). Standard Output is a measure of the standard value of the production of a farm. 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 per 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 substantial 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 89% of the total acreage of cultivated land, as is apparent from Table B1.2; 11% of the acreage is found on other farms types. These farms were also included in the monitoring network in order to obtain a sample that is optimally representative of the different crop rotations and fertilisation practices. Non-dairy farms account for approx. 25% of all farms (see Table B1.1). 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.

B1.5 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.

B1.6 Classification according to soil type region and district

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.

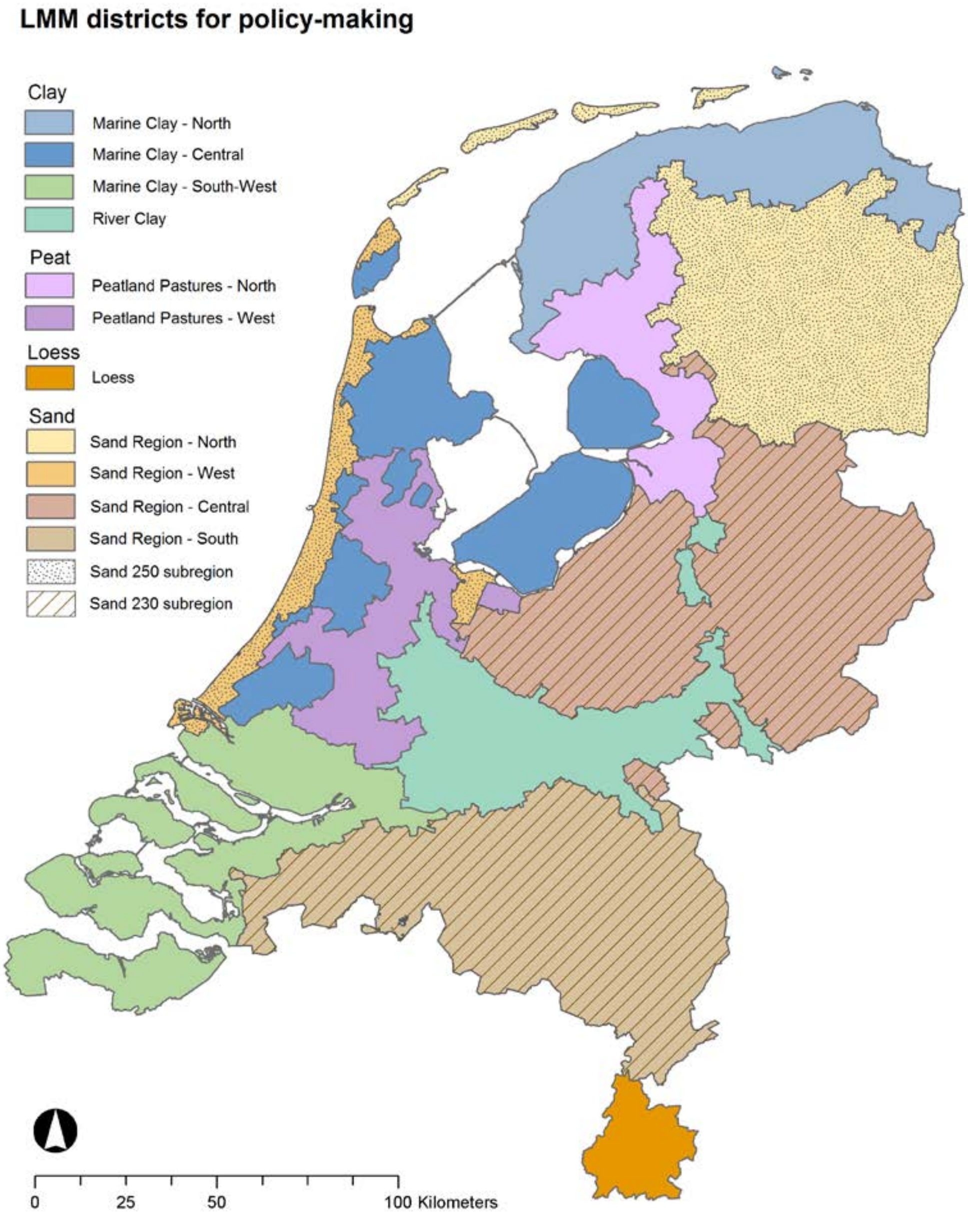

Figure B1.1 Soil type regions and districts for policy-making purposes in the Minerals Policy Monitoring Programme (LMM)

In the 2006-2013 period, stratification within the regions was based on groundwater body (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 district coincided with the transition from classification based on municipal boundaries to a (more accurate and stable) classification of regions and districts based on postcode districts (from FADN 2013 onward).

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 representativeness 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, Meuse, Rhine Middle, 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 because it includes multiple groundwater bodies without one body being clearly dominant. In addition, three groundwater bodies were distinguished as subregions: 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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Websites

Website of Statistics Netherlands, Agricultural Census data: http://statline.cbs.nl
Website of Koeien & Kansen: http://www.koeienenkansen.nl

Appendix 2 Monitoring of agricultural characteristics

This appendix explains how the agricultural practice data in the FADN network maintained by Wageningen Economic Research were monitored, and how these data were used to calculate fertiliser usage (section B2.2), grass and silage maize yields (section B2.3), and nutrient surpluses (section B2.4). Finally, the last section (B2.5) describes which significant changes were implemented in the calculation method and points of departure in comparison to the calculation method and points of departure of the derogation report released in 2018.

B2.1 General

Wageningen Economic Research 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% of total agricultural production in the Netherlands (Poppe, 2004; Binternet, 2013). Approx. 45 full-time Wageningen Economic Research employees are tasked 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. Wageningen Economic Research 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 as physical flows are registered in addition to financial flows.

Most FADN data that are converted into annual totals are subsequently 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. The consumption of fertilisers per crop is also known and is calculated per growing season as well as per year. Fertiliser usage is registered for each crop, and the data allow for calculations of usage per year and per growing season.

Fertiliser usage, yields, and nutrient surpluses are expressed per unit of surface area. The total acreage of land under cultivation in the Netherlands is used for these calculations. This is the land actually fertilised and used for crop cultivation on farms. 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).

B2.2 Calculation of fertiliser usage

The derogation decision (EU, 2018) stipulates that the report should include data on fertiliser usage and crop yields (Article 11 (1a). This article states (section 1.2):

'The competent authorities shall ... submit to the Commission every year a report containing the following information: data related to fertilisation on all farms which benefit from an individual derogation, including information on yields and on soil types.'

Nutrient usage data are differentiated for five different regions (Clay Region, Peat Region, Sand Region (230 and 250), and Loess Region). Fertiliser usage at farm level is reported, and a distinction is made between the use of fertilisers on arable land and on grassland.

B2.2.1 Calculation of fertiliser usage

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 (Netherlands Enterprise Agency, 2019, 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 based on the standard nitrogen quantities prescribed by law and the phosphate quantities reported by the Working Group on Uniform Mineral and Manure Excretions (WUM). This applies only if the stable balance method cannot be used.

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 by factors derived from data on standard compositions (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 (Netherlands Enterprise Agency, 2019, Table 5). If no sampling results are available, the output of on-farm manure is calculated based on the farm-specific mineral content per m^3 of manure, provided that the relevant farm uses the Farm-Specific Excretion (BEX) method or the stable balance method. Standard quantities are used for the other farms.

The total quantity of fertiliser used at farm level is subsequently 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 Economic Affairs, 2015). For these farms, the manure production is not calculated on the basis of standard quantities but on the basis of farm-specific data, if the farm indicates that it wishes to use the farm-specific excretion method. However, in some cases, the farm-specific calculation of manure production is nevertheless rejected, namely if the criteria mentioned in section B2.3.2 are not complied with. In these cases, the manure production is determined on the basis of standard quantities.

As of 1 May 2015, the guidance document on farm-specific excretion by dairy cattle is used to calculate the farm-specific excretion of the dairy herd (Ministry of Economic Affairs, 2015). The calculation method used deviates from the guidance document in two respects (Ministry of Economic Affairs, 2015):

- The uptake from silage maize expressed in fodder units is derived directly (as also applied in Aarts *et al*., 2008) from the silage maize yields reported by the farmer, corrected for stocks. 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 exact number of grazing hours reported by the farmer, whereas in the guidance document (Ministry of Economic Affairs, 2015) and in Aarts *et al*. (2008), three classes are defined based on the reported grazing.

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, the quantities applied, and the 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 farm-specific mineral content if the manure production is calculated separately for each farm (see above); or, if this is not the case
- the applicable standard contents (Netherlands Enterprise Agency, 2019, Table 5).

The quantity of fertiliser applied on grassland is calculated as the closing entry:

Usage on grassland =
fertiliser usage at farm level - fertiliser usage on arable land

In the case of farms where grassland accounts for less than 25% of the total cultivated area[2], fertiliser usage on grassland is calculated based on the quantity of organic fertilisers registered in FADN, and the fertiliser usage on arable land is calculated as the closing entry. The quantity of fertiliser used on grassland comprises fertilisers spread on the land and manure excreted directly by grazing animals on grassland (grassland manure). The quantity of nutrients in grassland manure is calculated for each animal category by multiplying the calculated excretion by the percentage of the year that the animals spend grazing.

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 (Netherlands Enterprise Agency, 2019, Table 3). The quantity of nitrogen from inorganic fertilisers with an availability coefficient of 100% is added to the outcome.

If dairy cows graze on the farm, the legally applicable availability coefficient is lower (45% instead of 60% since 2008) for all grazing livestock manure produced and applied 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 (Netherlands Enterprise Agency, 2019, 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.

B2.2.2 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 also applies to total fertilisation (i.e. inorganic fertilisers + livestock manure + other organic fertilisers). The lower limits for the various types of fertiliser are static. The upper limits are dynamic and depend on the application standards for nitrogen, animal manure, or phosphate. The farm-specific application standard is multiplied by a factor of 2.5. Table B2.1 lists the confidence intervals for non-organic dairy farms.

[2] Not relevant for this report, as a minimum of 70% (80% as of 2014) grassland is required for derogation.

Table B2.1 Lower and upper limits on non-organic dairy farms for applied quantities of inorganic fertilisers, livestock manure, and other organic fertilisers, and total quantities of fertilisers applied (inorganic fertilisers + livestock manure + other organic fertilisers)[1, 2]

Nutrient and type	Lower or upper limit	Available margin[3] or value (kg/ha)	Factor
Nitrogen			
Inorganic fertilisers	Lower limit	0	-
Inorganic fertilisers	Upper limit	SGR	2.5
Livestock manure	Lower limit	0	
Livestock manure	Upper limit	GDM (available margin for animal manure)	2.5
Other organic fertilisers	Lower limit	0	-
Other organic fertilisers	Upper limit	SGR	2.5
Total fertiliser usage	Lower limit	50	
Total fertiliser usage	Upper limit	SGR (available margin for nitrogen)	2.5
Phosphate			
Inorganic fertilisers	Lower limit	0	
Inorganic fertilisers	Upper limit	FGR	2.5
Livestock manure	Lower limit	0	
Livestock manure	Upper limit	FGR	2.5
Other organic fertilisers	Lower limit	0	
Other organic fertilisers	Upper limit	FGR	2.5
Total fertiliser usage	Lower limit	25	
Total fertiliser usage	Upper limit	FGR	2.5

[1] If a value falls outside the upper and lower limits listed in Table B2.1, the nutrient flows of the relevant farm are considered incomplete and the farm is not included for the purpose of nutrient flow calculations.
[2] This table only states the lower and upper limits for fertiliser usage at farm level on non-organic dairy farms. Other limits are applied to other types of farms. Lower and upper limits are also applied to other quantities and indicators.
[3] Available margin for nitrogen (SGR), available margin for livestock manure (GDM), available margin for phosphate (FGR), average per farm per hectare.

B2.3 Calculation of grass and silage maize yields

B2.3.1 Calculation procedure

The calculation procedure for determining grass and silage maize yields in FADN is largely identical to the procedure described in Aarts *et al.* (2005, 2008). First, the energy requirement of the dairy herd is determined 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 subsequently determined based on measurements and content data for silage supplies, insofar as these are available. The silage maize yield is subsequently 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 subsequently 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 subsequently 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 (in kilogrammes) for grassland are calculated by adding to the uptake the average quantities of N, P, kVEMs and dry matter lost during feed production and conservation.

B2.3.2 *Selection criteria*

The calculation procedure described above cannot be applied to all farms. On mixed farms, it is often difficult to clearly separate the product flows between different production units. The method is applied in accordance with Aarts *et al*. (2008).

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

- At least 15 hectares used for cultivation of fodder crops
- At least 30 persons
- Annual milk production of at least 4500 kg of Fat and Protein Corrected Milk (FPCM) per cow

These criteria were ignored as, in the study by Aarts *et al*. (2008), they were used to draw conclusions with regard to the population of "conventional" dairy farms. These criteria can be ignored because the population data have already been registered in the permanent derogation monitoring network (comprising 300 farms). In addition, with regard to the results, in accordance with Aarts *et al*. (2008), the following confidence intervals were used for yields:

- silage maize yields: 5,000 to 25,000 kg of dry matter per hectare;
- grassland yields: 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 book-keeping error. In that case, the grass and silage maize yields of the farms concerned are also excluded from the report.

B2.3.3 *Deviations from procedure described in 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 the LMM model.
This concerns the following data:

1. composition of silage grass and silage maize;
2. Mobility factor 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
In Aarts *et al* (2008), the composition of silage grass and silage maize pits is based on provincial averages supplied by the Netherlands Laboratory for Soil and Crop Research (BLGG). A slightly different method is used in the FADN network. 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% of all silage pits have been fully sampled. The average pit composition for each soil type is used if less than 80% 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 Eurofins Agro (formerly BLGG).

Re 2
A so-called 'mobility factor' is taken into account when calculating the energy requirement. This mobility factor depends on the number of grazing days, among other things. Aarts *et al*. (2008) distinguish three grazing categories: no grazing (0 grazing days), less than 138 grazing days, and more than 138 grazing days. The exact number 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 Economic Affairs, 2015).

Re 3
The distribution of the energy uptake from fresh grass and silage grass is, in contrast to Aarts *et al*. (2008), also based on the number of grazing days registered in the FADN and/or 'zero grazing days'. The percentage of fresh grass varies between 0 and 35% for zero grazing, between 0 and 40% for unlimited grazing, and between 0 and 20% for limited grazing. This calculation is also performed in accordance with the method described in Appendix 2 to the guidance document (Ministry of Economic Affairs, 2015).

Re 4
The information appendix lll from 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 B2.2.

Table B2.2 Percentages used to calculate conservation losses and feed production losses[1]

Category	Conservation losses				Feed production losses
	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

[1] The percentage for conservation losses is a percentage of the quantity put to or in the feed storage facility.
The percentage for feed production losses is a percentage of the same quantities after deducting the conservation losses In other words, 100 kg (dry matter) of silage grass in the silage pit corresponds to 90 kg of dry matter after conservation and 85.5 kg of dry matter consumed by the animal.

B2.4 Calculation of nutrient surpluses

In addition to fertiliser usage and crop yields, the report also states the nitrogen and phosphate surpluses on the soil surface balance (in kg of nitrogen and phosphate per hectare, respectively). 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 immobilisation of nitrogen and phosphate in the soil is equal to the mineralisation of nitrogen and phosphate in the soil. An exception to this rule is made for peat soils and reclaimed peat subsoils. With these soil types, 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 on reclaimed peat subsoils or other crops on peat soils and reclaimed peat subsoils. It is known that net mineralisation occurs on these soils as a result of groundwater level management, which is necessary in order to use the land for agriculture. 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 bookkeeping 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 B2.3. The surplus at farm level 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 at farm level is subsequently corrected to account for a number of input and output items to and from the soil and the air. The phosphate surplus on the soil surface balance is equal to the surplus at farm level. A more detailed explanation of the calculation methods can be found in Table B 2.3 below.

Table B 2.3 Calculation methods used to determine the nitrogen surplus on the soil surface balance (kg N/ha^{-1} year^{-1})

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 for nitrogen and phosphate concentrations 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 (Netherlands Enterprise Agency, 2019, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section B2.2).
Feedstuffs	Balance of all inputs 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 data compiled by Statistics Netherlands (2010, 2011). As of 2010, all compound feed data are calculated for each farm. Standards for silage grass and silage maize are based on annual averages for the different soil type regions (data supplied by Eurofins).
Animals	Only imported animals	Standard quantities based on Ministry of Economic Affairs, 2015, and Netherlands Enterprise Agency, 2019, Table 7).
Plant products (sowing seeds, young plants and propagating material)	Only imported plant products	Data based on Van Dijk, 2003

Description of items	Calculation method	
	Quantity	Contents
Other	Balance of all inputs, outputs and stock changes of all other 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	Netherlands Enterprise Agency (2019), Tables 7 and 8
Animals	Balance of outputs and stock changes of animals and meat	Netherlands Enterprise Agency (2019), 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 (Netherlands Enterprise Agency, 2019, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section B2.2).
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	Data based on Van Dijk, 2003 and CVB, 2012
Other	Balance of all inputs, outputs and stock changes of all other products in the case of net production (output)	
Nitrogen surplus at farm level	Farm input minus Farm output	
Input on soil surface balance		
+ Mineralisation	For grass on peat soils: 160 kg N/ha/year (based on van Kekem, 2004); other crops on peat soils as well as reclaimed peat subsoils (irrespective of crop): 20 kg N/ha/year; all other soils: 0 kg. In the case of FADN farms, the surface areas are registered according to the four soil types defined by the Netherlands Enterprise Agency (sand, clay, peat and loessial soils). Mineralisation in reclaimed peat subsoils was estimated based on the overall soil classifications of each farm (based on postcode), in accordance with the Alterra soil map, version of 2006 (2006).	
+ Atmospheric deposition	The basic data are derived from National Institute for Public Health and the Environment (2019).	

Description of items	Calculation method	
	Quantity	Contents
+ Nitrogen fixation by leguminous plants	Clover on grassland (Kringloopwijzer, 2013): the quantity of nitrogen fixation depends on the proportion of clover (relationship between proportion of clover and clover density = 0.82; correction takes place) and the grassland yield, and is based on a nitrogen fixation per kg of dry-matter yield in the form of clover of (4.5/100). Other crops (Schröder, 2006): for Lucerne: 160 kg N/ha for peas, broad beans, brown beans and French beans: 40 kg/ha	
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 emission resulting from stabling and storage: the stable codes under the Regulations on the Use of Ammonia in Livestock Farming (Regeling Ammoniak en Veehouderij, RAV) are used as a starting point. The total nitrogen emitted is calculated as a percentage of the total ammonia nitrogen (TAN) excreted (based on the RAV emission factor). The TAN excreted is determined on the basis of the TAN percentages in the manure (Van Bruggen *et al*., 2017). The calculations take into account mineralisation and immobilisation of nitrogen in solid manure and slurry manure (Van Bruggen *et al*., 2017). Ammonia emission during grazing is calculated as a percentage (4%) of the TAN excreted during grazing (Van Bruggen *et al.,* 2017). If a farm calculates excretion based on standard quantities, the emissions resulting from grazing, stabling and storage are calculated as follows: First, the gross standard-based excretion is calculated by adding the standard-based emission factor to the net standard-based excretion (Groenestein *et al.,* 2005, Tamminga *et al*., 2014, Oenema *et al*., 2000, Groenestein *et al*., 2015). This factor depends on the type of animal. The emissions resulting from grazing are subsequently calculated by multiplying the quantity of nitrogen- excreted in grassland manure (net standard-based excretion for grassland fraction) by the emission percentage of the TAN excreted on grassland (Van Bruggen *et al.,* 2017). 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) and Van Bruggen *et al*. (2017). 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),	

Description of items	Calculation method	
	Quantity	Contents
	an average percentage 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 TAN factor.	
Nitrogen surplus on the soil surface balance	Nitrogen surplus on farm + input on soil surface balance – output on soil surface balance	

B2.5 Changes in calculation method and points of departure

This year, the confidence intervals for the application of inorganic fertilisers, animal manure, and other organic fertilisers were adjusted retroactively for the entire period. As a result, the upper limits were made dependent upon the average farm-specific margins available for the application of nitrogen, animal manure, and phosphate.
The lower limits were not adjusted. This modification ensures that the checks carried out on the data for the application of fertiliser focus more on the plausibility of farm-specific data than was previously the case. The confidence intervals can now also change in line with possible policy modifications regarding the available application margin.

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Appendix 3 Sampling of water on farms in 2019

B3.1 Introduction

The derogation decision (EU 2018, see section 1.2) states that a report must be produced on the development of water quality, and that this report must be based, among other things, on monitoring of water leaching from the root zone as well as surface and groundwater quality (Article 10, paragraph 1(f) and 1(g)). The monitoring of the quality of shallow groundwater, soil water, and streams on farms belonging to the monitoring network yields data about the nitrate and phosphorus concentrations in water leaving the root zone and ending up in the groundwater and surface water system (Article 8 (5)).

B3.1.1 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 Region and Peat Region is higher. The average groundwater level is usually 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 into the 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 is sampled below the root zone. There is little agricultural activity on push moraines in the Sand Region where the water table is far below ground level. Where these agricultural activities do occur, the soil moisture below the root zone is also 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 leaching of water from the root zone is monitored by sampling the topmost metre of groundwater and/or the tile drainage water. In addition, the input of nutrients into the surface water in the Low Netherlands is monitored by sampling ditch water.

In this report, the water leaching from the root zone is also referred to as ‘leaching water’ or simply ‘leachate’. In the Sand Region, the water leaching from the root zone is therefore monitored by taking samples of the groundwater and, in exceptional cases, samples of soil moisture. In the Clay Region, samples are taken of groundwater or drainage water, in the Peat Region samples are taken of groundwater, and in the Loess Region, the soil moisture is sampled.

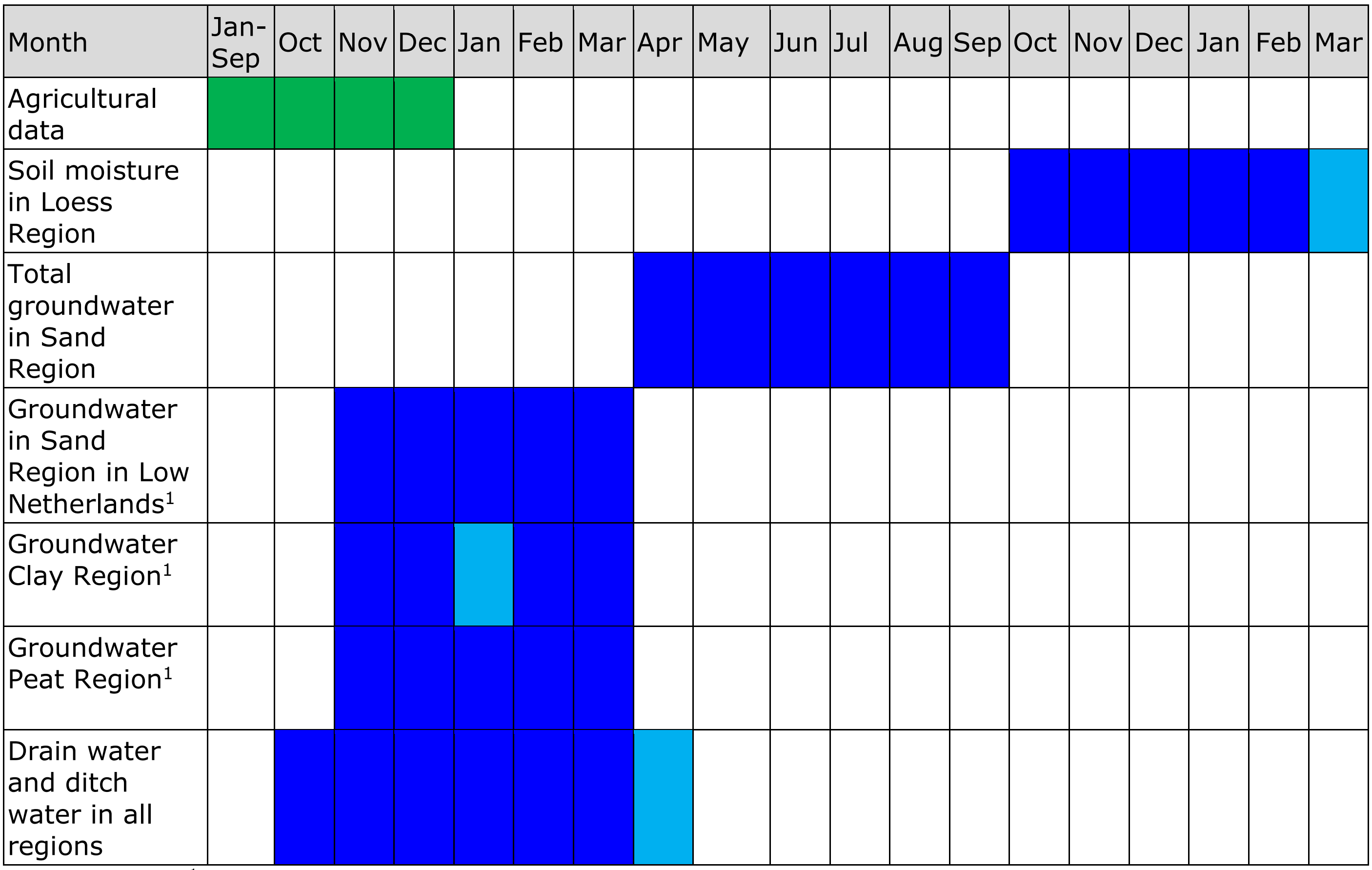
B3.1.2 Number of measurements per farm

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).

B3.1.3 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 loessial 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 B3.1) has been chosen in such a manner that the measurements are properly representative of water leaching from the root zone, and thus reflect the agricultural practices of the previous year as accurately as possible. Due to weather conditions, sampling campaigns may need to be extended or started at a later time.

In the High Netherlands, groundwater and soil moisture are sampled once a year on each farm. The average precipitation surplus in the Netherlands is approximately 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 expected to be representative of the water leaching from the root zone every year, and of 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 in a single year and between years can be eliminated when dilution effects and groundwater level variations are taken into account (Fraters *et al.*, 1997).



[1] The exact date on which sampling is started depends on the amount of precipitation. Sufficient precipitation must have fallen before leaching into groundwater occurs. Sampling never starts later than 1 December. Dates which are subject to potential changes are indicated by months displayed in lighter colours.

Figure B3.1 Relationship between data on agricultural practices in a specific year and the water sampling period that has provided the data linked to these agricultural data, for all regions defined in the Minerals Policy Monitoring Programme (LMM)

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 (the intended LMM sampling frequency). This higher sampling frequency allows for better 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 Region 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 a request from the European Commission. 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. Sampling was performed in accordance with the applicable work instructions. The text below refers to the applicable work instructions by stating the relevant document number. An overview of the work instructions concerned is provided at the end of this appendix.

B3.2 Sand Region and Loess Region

B3.2.1 Standard sampling procedure

Groundwater sampling on derogation farms in the Sand Region was carried out from April 2019 up to and including September 2019 (see Figure B3.2). In the Loess Region, samples were taken from October 2019 up to and including February 2020 (see Figure B3.2). Each farm was sampled once during these periods.

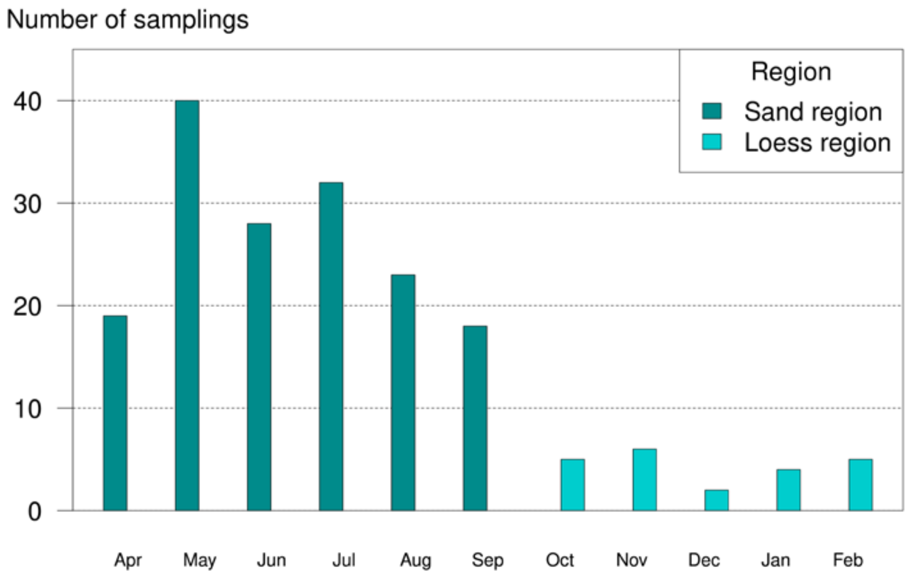


Figure B3.2 Number of samples taken of groundwater and soil moisture in the Sand Region and Loess Region per month in the period from April 2019 up to and including February 2020

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 (MIL-W-4021). The top metre of groundwater was sampled using the open bore hole method (MIL-W-4015). The groundwater levels and nitrate concentrations were determined in situ at each location (Nitrachek method, MIL-W-4001). The water samples were filtered and stored in a cool dark place prior to transport to the laboratory (MIL-W-4008). 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 (MIL-W-4009). Soil moisture samples were taken by collecting drill cores at depths ranging from 150 to 300 cm, using an Edelman drill. The samples were subsequently transported to the laboratory in untreated form and packed in tightly sealed containers (MIL-W-4014). 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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

B3.2.2 Additional sampling in low-lying sandy areas

On farms in the Sand Region, additional ditch water samples were taken during the period from November 2018 up to and including March 2019 (see Figure B3.3). Samples were taken in accordance with the standard method. On each farm, no more than two types of ditches were distinguished: farm ditches and local ditches. Farm ditches only 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, 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 (MIL-W-4021). 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.

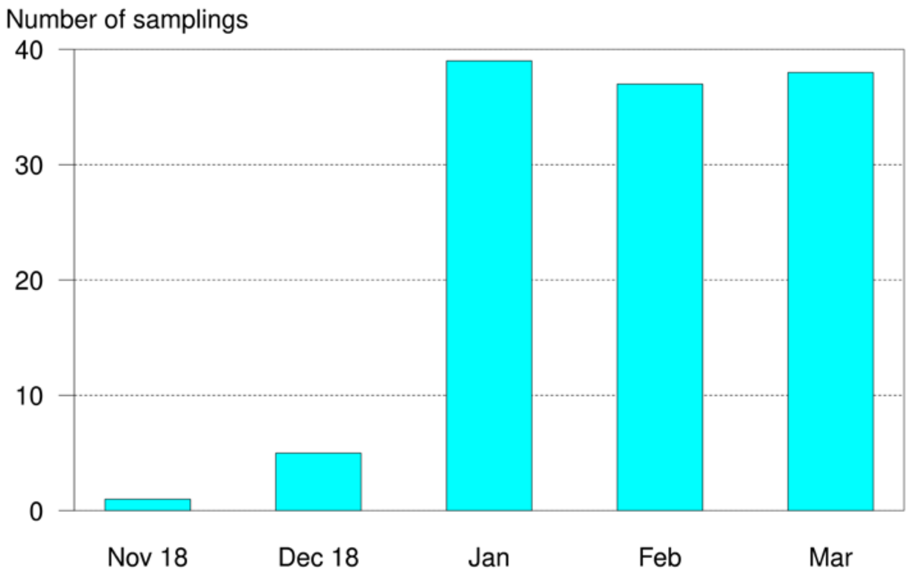


Figure B3.3 Number of ditch water samples in the Sand Region per month during the period from October 2018 up to and including March 2019

Three to four ditch water samples were taken on these farms in the winter of 2018-2019. Due to the dry summer of 2018 and the small quantity of precipitation in October, November, and December (2018), the first samples of ditch water were not taken before January on a great many farms. The ditchwater samples were taken using a measuring beaker attached to a stick or 'fishing rod' (MIL-W-4011). Water samples were stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). The ditchwater samples were filtered in the laboratory on the next day, and two compound samples were prepared (one for each ditch type). The individual ditch water samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen and total phosphorus content. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

B3.3 The 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% of its acreage is drained using drainage pipes, or if less than 13 drains can be sampled. Different sampling strategies are used on farms with drainage and farms without drainage.

B3.3.1 Farms with drainage

On farms with drainage, drain water and ditch water were sampled during the period from December 2018 up to and including April 2019 (see Figure B3.4). 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 (MIL-W-4021). On each farm, two ditch types were distinguished. For each ditch type, up to four sampling locations were selected (see section B3.2). 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.

During the winter of 2018-2019, drain water and ditch water were sampled between one and four times using the method described in the previous section. Samples were taken throughout the winter; the minimum period between two sampling dates was three weeks.

Water samples were stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). The next day, the samples were filtered in the laboratory and one compound sample was prepared from the drain water samples in the laboratory, and two compound samples were prepared from the ditchwater samples (one for each ditch type). The individual drain water and ditchwater samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen content and total phosphorus content. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

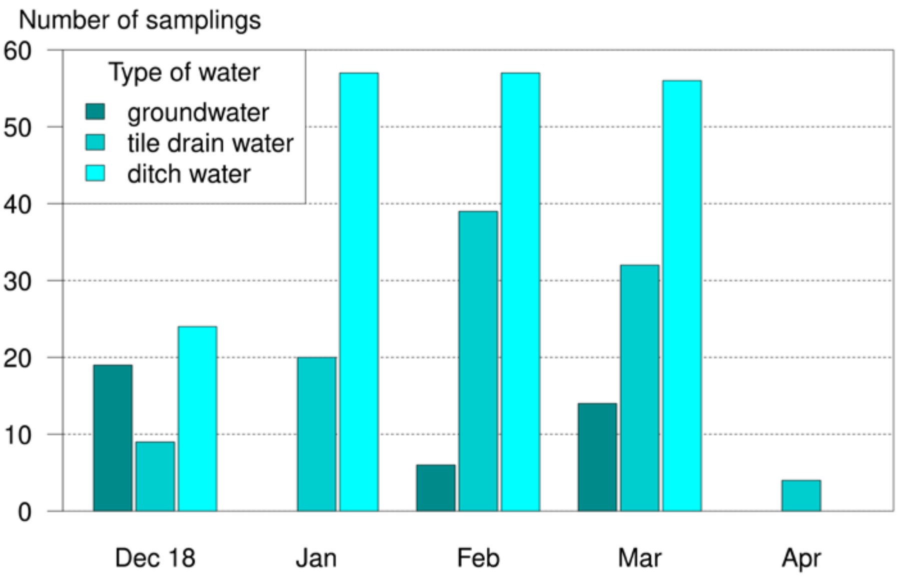


Figure B3.4 Number of groundwater, drain water, and ditch water samples taken in the Clay Region per month during the period from December 2018 up to and including April 2019

B3.3.2 *Farms without drainage*

On farms without drainage, samples were taken of the top metre of groundwater and ditch water during the period from November 2018 up to and including April 2019 (MIL-W-4021) (see Figure B3.4). On these

farms, groundwater samples were taken once or twice, and ditchwater samples were taken a minimum of one time and a maximum of 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 (MIL-W-4015) 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, MIL-W-4001). The water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). 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 (MIL-W-4009). 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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).
The ditchwater samples were taken in a manner similar to the method used on farms with drainage, i.e. two ditch types were defined, with up to four sampling locations per ditch type.

B3.4 The Peat Region

In the Peat Region, the top metre of groundwater was sampled once on all farms during the period from November 2018 up to and including March 2019 (see Figure B3.5). In the same period, three to four ditchwater samples were taken on these farms.

The groundwater was sampled using a method similar to the one employed in the Sand Region and Clay Region. However, the reservoir tube method (MIL-W-4015) 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, MIL-W-4001). The water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). 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 (MIL-W-4009). 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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

The ditchwater was sampled using a method similar to the one employed in the Sand Region and Clay Region. The ditchwater samples were taken using a measuring beaker attached to a stick or 'fishing rod' (MIL-W-4011). Water samples were stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). The ditchwater samples were filtered in the laboratory on the next day, and two compound samples were prepared (one for each ditch type). The individual ditch water samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen and total phosphorus content. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

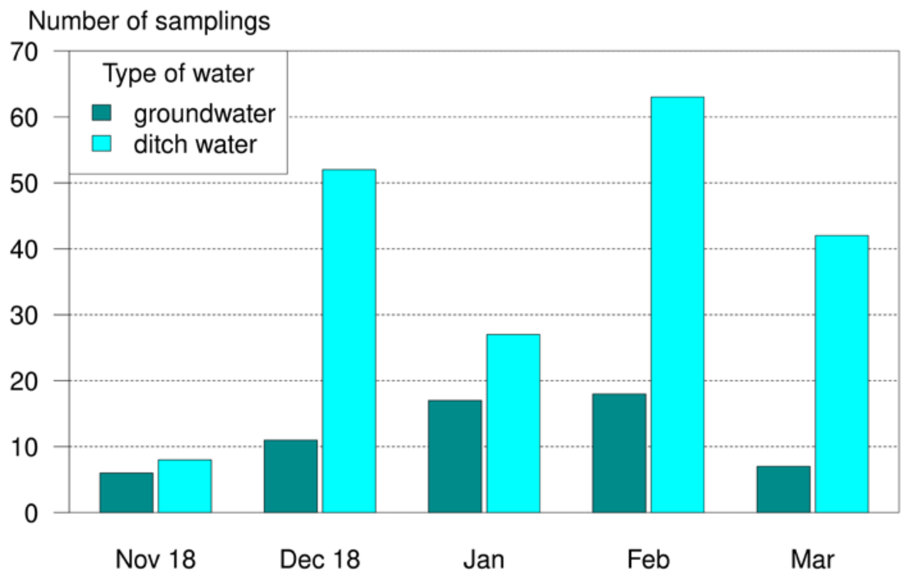


Figure B3.5 Number of groundwater and ditch water samples taken in the Peat Region per month during the period from November 2018 up to and including March 2019

The following RIVM work instructions were used

MIL-W-4001	Measuring nitrate concentrations in aqueous solutions using a Nitracheck reflectometer (type 404)
MIL-W-4008	Temporary storage and transportation of samples
MIL-W-4009	Method for conserving water samples by adding acid
MIL-W-4011	Sampling ditchwater or surface water using a modified sampling lance and peristaltic pump
MIL-W-4014	Soil sampling using an Edelman drill for soil moisture analysis purposes
MIL-W-4015	Groundwater sampling using a sampling lance and peristaltic pump on sand, clay or peat soils
MIL-W-4021	Determining sampling locations

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Appendix 4 Derogation monitoring network results by year

Table B 4.1 Some general characteristics of farms participating in the derogation monitoring network (DMN) in the 2006-2019 period: average values for the 2006-2018 period, difference between 2019 results and the average value for the 2006-2018 period, and the trend identified for the 2006-2019 period

Farm characteristic	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**2006-2018**	**Difference**	**Trend**
Number of dairy farms	251	247	253	250	253	256	263	255	251	258	264	260	255	260	255		
Number of other grassland farms	43	48	43	43	41	33	32	33	36	30	33	33	36	35	37		
Total area of cultivated land (hectares)	42	42	42	43	44	44	46	46	48	48	50	50	52	54	46	+	+
Proportion of grassland (%)	83	83	83	83	84	84	84	84	86	88	88	87	88	88	85	+	+
Proportion of farms with intensive livestock (%)	14	14	13	11	10	8	5	5	5	6	4	5	5	6	8	-	-
Total livestock density (LSUs/ha) [1]	2.5	2.5	2.6	2.6	2.7	2.5	2.4	2.4	2.5	2.6	2.6	2.5	2.4	2.4	2.5	-	-
Kilogrammes of FPCM per dairy farm (x 1,000)	603	614	660	692	734	743	737	774	819	862	921	962	983	1027	777	+	+
FPCM production per hectare of fodder crop (x 1,000 kg)	14	14	15	15	16	16	15	16	16	17	18	18	18	18	16	+	+
Kilogrammes of FPCM per dairy cow (x 1,000)	8.4	8.4	8.4	8.5	8.7	8.6	8.5	8.5	8.6	8.8	8.9	9.2	9.4	9.5	8.7	+	+
Percentage of dairy farms where dairy cows graze:																	
• May-October	89	89	84	82	82	80	81	81	79	79	83	83	87	88	83	+	≈
• May-June	86	85	80	78	77	76	79	76	78	78	82	82	87	88	80	+	≈
• July-August	88	89	84	82	81	79	81	81	79	79	82	83	85	87	83	+	-
• September-October	89	87	82	79	77	72	77	78	78	77	81	78	81	83	80	-	-

[1] Phosphate Livestock Unit (LSU) is a unit used to compare numbers of animals based on their standard phosphate production. One adult dairy cow = 41 kg of phosphate on average, which is equivalent to 1 LSU. One young animal 1-2 years of age = 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). 15505 Tabellenbrochure MINAS. (MINAS Tables brochure).

Difference: direction and significance of difference between 2019 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).

Trend: direction and significance of trend in 2006-2019 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table B4.2 Average application of nitrogen in livestock manure (in kg N/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2019 period: average values for the 2006-2018 period, difference between 2019 results and the average value for the 2006-2018 period, and trends identified for the 2006-2019 period

Description	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	2006-2018	Difference	Trend
Number of farms	278	285	283	280	287	280	283	280	277	279	289	279	277	279	281		
Produced on farm	260	261	261	262	276	270	248	260	281	291	293	288	288	271	272	+	+
+ Inputs	9	12	13	12	10	14	15	13	10	8	7	11	9	8	11	≈	+
+ stock changes[1]	-5	-14	-7	-3	-8	-7	-5	-6	-13	-11	-2	-7	0	-2	-7	-	-
– Outputs	22	29	31	35	37	38	29	30	40	53	58	50	51	48	39	+	+
Total use	242	230	236	236	240	239	230	237	238	236	240	242	246	230	238	-	≈
Number of grassland farms[2]	272	281	273	269	275	266	266	264	268	270	279	267	261	269	270		
Use on grassland	256	241	253	251	255	254	240	250	250	245	247	253	258	238	250	-	-
Number of arable farms[3]	200	205	206	202	199	198	195	198	197	201	207	201	195	206	200		
Use on arable farms	182	177	167	170	174	173	176	178	181	185	189	177	187	183	178	≈	+

[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 a smaller number of farms, as the allocation of fertilisers on arable land for a number of farms did not fall between the lower and upper limits.
[3] The average use on arable land is based on a smaller number of farms, as, in addition to the fact that the allocation of fertilisers on arable land for a number of farms did not fall between the lower and upper limits, a number of farms did not have any arable land.
Difference: direction and significance of difference between 2019 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2019 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table B4.3 Average application of nitrogen (in kg plant-available N/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2019 period: average values for the 2006-2018 period, difference between 2019 results and the average value for the 2006-2018 period, and the trend identified for the 2006-2019 period

Description	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	2006-2018	Difference	Trend
Number of farms	278	285	283	280	287	280	283	280	277	279	289	279	277	279	281		
Livestock manure excluding availability coefficient	242	230	236	236	240	239	230	237	238	236	240	242	246	230	238	-	≈
Availability coefficient	40	40	48	49	49	49	50	49	49	49	49	49	48	49	48	≈	+
Animal manure based on statutory availability coefficient	97	94	114	116	118	119	114	116	117	117	118	119	119	111	114	-	+
+ Other organic fertilisers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	≈	≈
+ inorganic fertilisers	130	129	129	133	126	125	124	127	141	136	138	143	122	126	131	-	≈
Total use	227	223	243	249	244	243	238	243	258	253	256	261	241	236	245	-	+
Nitrogen application standard applicable to farm	293	288	276	267	265	265	264	263	278	282	281	281	277	279	275	≈	-
Number of grassland farms[1]	272	281	273	269	275	266	266	264	268	270	279	267	261	269	270		
Use on grassland	251	245	272	276	270	268	258	268	281	271	272	283	262	254	267	-	≈
Nitrogen application standard for grassland	322	319	302	293	289	288	287	286	301	302	301	303	301	301	300	≈	-
Number of arable farms[2]	200	205	206	202	199	198	195	198	197	201	207	201	195	206	200		
Use on arable farms	111	120	123	122	127	126	127	123	129	131	132	126	131	128	125	≈	+
Nitrogen application standard for arable land	156	157	161	154	155	155	150	147	147	144	143	144	145	146	151	-	-

[1] The average use on grassland is based on a smaller number of farms, as the allocation of fertilisers on arable land for a number of farms did not fall between the lower and upper limits.
[2] The average use on arable land is based on a smaller number of farms, as, in addition to the fact that the allocation of fertilisers on arable land for a number of farms did not fall between the lower and upper limits, a number of farms did not have any arable land.
Difference: direction and significance of difference between 2019 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2019 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table B4.4 Average application of phosphate (in kg P_2O_5/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2019 period: average values for the 2006-2018 period, difference between 2019 results and the average value for the 2006-2018 period, and the trend identified for the 2006-2019 period

Description	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**2006-2018**	**Difference**	**Trend**
Number of farms	278	285	283	280	287	280	283	280	277	279	289	279	277	279	281		
Livestock manure	88	84	86	86	85	84	81	80	81	78	78	76	75	72	82	-	-
+ Other organic fertilisers	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	≈	≈
+ inorganic fertilisers	11	7	6	3	3	3	2	3	2	0	0	0	0	0	3	-	-
Total use	100	92	92	89	89	87	84	83	84	79	78	76	75	73	85	-	-
Phosphate application standard applicable to farm	108	103	97	98	91	91	88	87	88	84	84	84	84	84	91	-	-
Number of grassland farms[1]	272	281	273	269	275	266	266	264	268	270	279	267	261	269	270		
Use on grassland[1]	103	93	96	92	92	90	85	86	86	82	80	80	79	75	88	-	-
Phosphate application standard for grassland	111	106	100	101	94	94	92	92	92	88	88	88	88	88	95	-	-
Number of arable farms[2]	200	205	206	202	199	198	195	198	197	201	207	201	195	206	200		
Use on arable land[2]	90	88	83	78	76	76	74	72	78	66	64	60	59	60	74	-	-
Phosphate application standard for arable land	95	90	85	85	78	74	70	64	64	60	60	60	61	61	73	-	-

[1] The average use on grassland is based on a smaller number of farms, as the allocation of fertilisers on arable land for a number of farms did not fall between the lower and upper limits.
[2] The average use on arable land is based on a smaller number of farms, as, in addition to the fact that the allocation of fertilisers on arable land for a number of farms did not fall between the lower and upper limits, a number of farms did not have any arable land.
Difference: direction and significance of difference between 2019 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2019 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table B4.5 Calculated crop yields for grassland and estimated crop yields for silage maize (in kg of dry matter, nitrogen, phosphate and P_2O_5 per hectare) on farms participating in the derogation monitoring network that meet the criteria for application of the grassland yield calculation method (zie Bijlage 2), for the 2006-2019 period: average values for the 2006-2018 period, difference between 2019 results and the average value for the 2006-2018 period, and the trend identified for the 2006-2019 period

Description	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**2006-2018**	**Difference**	**Trend**
Estimated silage maize yield																	
Number of farms	168	163	161	173	168	169	165	176	173	180	191	177	174	190	172		
tonnes of dry matter per hectare	15.5	14.8	16.6	17.0	16.4	17.5	17.6	16.6	17.7	17.6	16.8	18.4	16.4	17.0	16.8	≈	+
kg N/ha	193	172	192	193	194	207	186	184	189	192	175	198	185	205	189	+	≈
kg P/ha	31	29	31	32	31	33	32	30	35	32	32	32	29	30	31	-	≈
Kilogrammes of P_2O_5 per hectare	70	67	71	73	71	76	74	68	79	72	74	73	67	70	72	-	≈
Calculated grassland yield																	
Number of farms	229	229	217	226	230	228	224	234	231	235	244	230	225	234	229		
tonnes of dry matter per hectare	10.9	10.8	10.4	10.6	9.7	11.0	10.2	9.4	11.0	10.5	11.2	10.0	8.3	9.7	10.3	-	-
kg N/ha	304	289	291	275	250	283	245	261	294	269	283	292	255	268	276	≈	≈
kg P/ha	38	42	41	38	34	39	37	34	45	37	39	37	27	32	38	-	-
kg P_2O_5/ha	87	96	95	86	79	90	85	78	102	84	90	84	62	73	86	-	-

Difference: direction and significance of the difference between 2019 and the average value in previous years, ≈ : no significant difference ($p > 0.05$), +/- : a significant difference ($p < 0.05$).
Trend: direction and significance of the trend for the period 2006-2019, ≈ : no significant trend ($p > 0.05$), +/- : a significant trend ($p < 0.05$).

Table B4.6 Nitrogen surplus on the soil surface balance (in kg N/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2019 period: average values for the 2006-2018 period, difference between 2019 results and the average value for the 2006-2018 period, and the trend identified for the 2006-2019 period

Description	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**2006-2018**	**Difference**	**Trend**
Number of farms	278	285	283	280	287	280	283	280	277	279	289	279	277	279	281		
Inputs of (organic and inorganic) fertilisers, feedstuffs, animals and other products	330	340	338	351	354	349	331	334	346	370	370	361	367	339	349	-	+
Outputs of milk, animals, feedstuffs, manure and other products	139	153	158	159	163	171	154	143	184	193	196	196	171	175	168	≈	+
Deposition, mineralisation and nitrogen fixation	64	65	63	64	54	59	57	55	56	54	55	53	50	50	58	-	-
Gaseous emissions resulting from stabling, storage, grazing and application	57	62	61	62	61	60	55	58	59	58	58	60	58	58	59	-	-
Surplus on soil surface balance																	
average	198	192	183	193	184	177	179	189	159	173	170	157	188	156	180	-	-
25th percentile[1]	134	123	130	135	130	125	127	140	102	121	117	111	136	108	126		
75th percentile[2]	243	245	220	226	217	211	214	222	194	210	210	200	230	188	219		

[1]Upper limit of the 25% of farms with the lowest surplus on the soil surface balance.
[2]Lower limit of the 25% of farms with the highest surplus on the soil surface balance.
Difference: direction and significance of the difference between 2019 and the average value in previous years, ≈ : no significant difference ($p > 0.05$), +/- : a significant difference ($p < 0.05$).
Trend: direction and significance of the trend for the period 2006-2019, ≈ : no significant trend ($p > 0.05$), +/- : a significant trend ($p < 0.05$).

Table B4.7 Nitrogen surplus on the soil surface balance (in kg N/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2019 period: average values for the 2006-2018 period, difference between 2019 results and the average value for the 2006-2018 period, and the trend identified for the 2006-2019 period

Region	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**2006-2018**	**Difference**	**Trend**
Sand-250 sub-region (n = 44-54)	163	170	168	174	166	173	165	179	143	160	154	158	153	140	163	-	-
Sand-230 sub-region (n = 87-110)	194	176	157	154	170	153	165	167	134	160	147	133	180	136	161	-	-
Loess Region (N = 15-20)	126	143	148	125	156	153	133	137	131	169	172	142	168	116	146	-	≈
Clay Region (n = 55-71)	191	191	192	215	174	173	169	182	158	162	174	154	183	156	178	-	-
Peat Region (N = 51-59)	254	243	230	249	240	228	231	244	214	220	215	201	237	204	231	-	-
All farms (N = 277-289)	198	192	183	193	184	177	179	189	159	173	170	157	188	156	180	-	-

Difference: direction and significance of the difference between 2019 and the average value in previous years, ≈ : no significant difference ($p > 0.05$), +/- : a significant difference ($p < 0.05$).
Trend: direction and significance of the trend for the period 2006-2019, ≈ : no significant trend ($p > 0.05$), +/- : a significant trend ($p < 0.05$).

Table B4.8 Average phosphate surplus on the soil surface balance (in kg P_2O_5/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2019 period: average values for the 2006-2018 period, differences between 2019 results and the average value for the 2006-2018 period, and the trend identified for the 2006-2019 period

Description	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**2006-2018**	**Difference**	**Trend**
Number of farms	278	285	283	280	287	280	283	280	277	279	289	279	277	279	281		
Inputs of (organic and inorganic) fertilisers, feedstuffs, animals and other products	88	84	84	84	86	83	74	78	75	84	78	76	84	74	81	-	-
Outputs of milk, animals, feedstuffs, manure and other products	59	69	68	69	72	73	66	60	81	80	80	76	68	70	71	+	+
Surplus on soil surface balance																	
average	29	15	15	15	15	10	8	18	-6	4	-2	-1	16	4	11	-	-
25th percentile[1]	11	-2	2	1	1	-2	-3	5	-24	-12	-15	-14	5	-9	-4		
75th percentile[2]	39	28	27	27	27	23	20	28	9	18	12	14	25	14	23		

[1] Upper limit of the 25% of farms with the lowest surplus on the soil surface balance.
[2] Lower limit of the 25% of farms with the highest surplus on the soil surface balance.
Difference: direction and significance of the difference between 2019 and the average value in previous years, ≈ : no significant difference ($p > 0.05$), +/- : a significant difference ($p < 0.05$).
Trend: direction and significance of the trend for the period 2006-2019, ≈ : no significant trend ($p > 0.05$), +/- : a significant trend ($p < 0.05$).

Table B4.9 Average nutrient concentrations (in mg/l)# in the water leaching from the root zone on farms participating in the derogation monitoring network in the 2007-2020 period: average values for the 2007-2019 period, difference between 2020 results and the average value for the 2007-2019 period, and the trend identified for the 2007-2020 period*

		'07	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**'20**	**2007-2019**	**Difference**	**Trend**
Sand-250	Number of farms	51	50	52	52	52	53	53	48	43	45	45	47	48	46			
	Nitrate	41	29	24	25	28	22	24	23	24	22	16	17	22	26	24	≈	-
	Phosphorus[1](P)	0.07	0.07	0.07	0.12	0.14	0.12	0.16	0.19	0.21	0.22	0.22	0.17	0.21	0.19	0.15	≈	≈
	Nitrogen (N)	12	9.9	8.4	8.8	9.5	8.6	8.6	8.6	8.9	8.6	7.2	7.2	8.5	9.3	8.9	≈	-
Sand-230	Number of farms	92	92	90	90	90	94	101	105	109	112	114	108	107	112			
	Nitrate	70	55	51	62	47	43	46	51	45	37	32	41	49	63	48	+	-
	Phosphorus (P)	0.10	0.09	0.10	0.09	0.11	0.11	0.09	0.12	0.12	0.11	0.12	0.14	0.10	0.11	0.11	≈	≈
	Nitrogen (N)	19	15	14	16	14	13	13	14	13	11	10	12	13	18	14	+	-
Loess Region[2]	Number	18	18	21	18	19	19	20	18	18	19	19	20	20				
	Nitrate	71	52	51	50	56	54	56	51	42	34	37	65	59		52	≈	≈
	Phosphorus[1](P)	<DT	<DT	<DT	<DT	**	<DT	<DT	<DT	<DT	**	**	<DT	<DT		<DT	≈	≈
	Nitrogen (N)	18	13	12	12	14	14	13	12	10	8.4	8.8	15	14		12	≈	-
Clay Region	Number of farms	63	67	67	67	65	59	66	60	60	60	60	57	56	57			
	Nitrate	24	16	14	19	14	11	11	15	22	13	16	14	42	37	18	+	+
	Phosphorus (P)	0.34	0.40	0.29	0.24	0.28	0.34	0.26	0.28	0.25	0.29	0.25	0.25	0.33	0.20	0.29	-	-
	Nitrogen (N)	8.6	6.0	5.3	6.4	5.2	4.8	4.6	5.4	6.6	4.9	5.4	5.1	11	10	6.1	+	+
Peat Region	Number of farms	50	50	50	49	49	51	57	57	58	59	58	55	58	56			
	Nitrate	15	6.2	6.9	13	7.3	4.7	6.4	10	14	6.9	6.3	6.8	15	12	9.1	≈	≈
	Phosphorus (P)	0.51	0.40	0.33	0.43	0.38	0.43	0.43	0.30	0.35	0.30	0.37	0.33	0.36	0.38	0.38	≈	-
	Nitrogen (N)	11	10	8.3	11	9.4	8.0	8.3	9.3	10	8.3	8.5	8.4	10	10	9.2	≈	≈

*The concentrations deviate from the final figures that are reported annually (see section 2.4.2 for the calculation method).
#In calculating average concentrations, this report dealt with the detection limits differently than previous reports. Historic figures can therefore deviate a bit from previous reports. **Phosphorus data were rejected in that year
[1] Average phosphorus concentrations below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT. [2] The data for 2020 are not yet available.
Difference: direction and significance of difference between 2020 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2007-2020 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table B4.10 Average nutrient concentrations (in mg/l)[*#] *in the ditch water*[1] *on farms participating in the derogation monitoring network in the 2007-2020 period: average values for the 2007-2019 period, difference between 2020 results and the average value for the 2007-2019 period, and the trend identified for the 2007-2020 period*

		'07	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**	**'14**	**'15**	**'16**	**'17**	**'18**	**'19**	**'20**	**2007-2019**	**Difference**	**Trend**
Sand-250	Number of farms	11	11	12	13	14	13	12	11	10	10	12	12	11	12			
	Nitrate	22	15	13	19	14	11	9.2	20	24	13	18	12	32	17	17	≈	≈
	Phosphorus (P)	0.29	0.24	0.46	0.17	0.13	0.18	0.16	0.18	0.21	0.25	0.17	0.20	0.15	0.25	0.21	≈	≈
	Nitrogen (N)	7.1	5.8	5.9	6.7	5.4	4.8	4.5	7.0	8.0	5.6	6.7	5.3	10	7.0	6.3	≈	≈
Sand-230	Number of farms	21	22	22	21	21	22	23	19	20	19	22	22	20	20			
	Nitrate	41	42	34	38	32	24	26	28	26	25	28	33	65	55	34	+	≈
	Phosphorus (P)	0.10	0.09	0.09	0.12	0.09	0.09	0.13	0.10	0.15	0.16	0.10	0.18	0.10	0.22	0.11	≈	≈
	Nitrogen (N)	11	11	9.4	11	9.2	7.7	8.1	8.7	8.3	8.1	8.5	10	16	15	10	+	≈
Clay Region	Number of farms	59	60	63	63	62	58	65	59	59	59	59	56	55	56			
	Nitrate	12	9.0	6.9	10	6.3	5.4	4.6	6.0	10	6.8	9.1	7.3	21	14	8.8	+	+
	Phosphorus (P)	0.33	0.36	0.36	0.23	0.27	0.26	0.26	0.27	0.22	0.29	0.24	0.26	0.15	0.24	0.27	≈	≈
	Nitrogen (N)	4.3	4.1	3.7	4.1	3.5	3.2	3.4	3.4	4.2	3.6	4.0	3.6	6.3	5.0	4.0	+	+
Peat Region	Number of farms	50	49	49	48	48	50	56	56	57	59	57	57	57	55			
	Nitrate	5.9	4.1	3.5	3.7	3.7	2.9	2.5	3.5	6.5	3.5	3.6	4.1	11	6.4	4.5	≈	+
	Phosphorus (P)	0.22	0.14	0.16	0.15	0.16	0.16	0.20	0.19	0.20	0.21	0.17	0.20	0.13	0.19	0.18	≈	-
	Nitrogen (N)	3.7	4.2	4.3	4.1	4.6	4.0	4.1	4.3	5.2	4.3	4.3	4.6	5.5	5.2	4.4	+	+

[*]The concentrations deviate from the final figures that are reported annually (see section 2.4.2 for the calculation method).
[#]In calculating average concentrations, this report dealt with the detection limits differently than previous reports. Historic figures can therefore deviate a bit from previous reports.
[1] There are no LMM farms with ditches in the Loess Region.
Difference: direction and significance of difference between 2020 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2007-2020 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table B4.11 Average nitrate concentration (mg/l), measured and corrected for weather conditions and variation in sampling population, in the water leaching from the root zone on farms participating in the derogation monitoring network in Sand-250; in addition, the average relative groundwater recharge, the groundwater level, the percentages of wetland and dry soils, the average month of sampling, and the differences between the years in standardised concentrations are presented.

Sand-250									
Year	**Number of farms**	**Relative groundwater recharge**	**Groundwater level (cm below surface level)**	**Wetland soils (%)**	**Dry soils (%)**	**Average sampling month[1]**	**Nitrate measured**	**Nitrate standard**	**Difference[2]**
2007	52	1.4	143	34	7	9.0	41	34	C
2008	51	1.0	144	34	5	9.7	29	32	BC
2009	54	1.0	165	33	6	9.2	24	27	ABC
2010	54	1.2	158	33	6	9.7	25	25	ABC
2011	54	1.4	151	34	4	8.5	28	24	AB
2012	53	1.3	145	34	4	8.5	22	19	A
2013	53	1.1	152	33	4	8.4	24	24	AB
2014	48	1.2	147	34	4	8.7	23	23	AB
2015	43	1.2	153	34	2	8.3	24	25	ABC
2016	45	1.1	151	36	3	8.5	22	23	AB
2017	45	1.0	177	36	3	9.1	16	20	A
2018	47	1.3	176	37	3	8.7	17	18	A
2019	48	1.2	194	39	3	8.4	22	25	ABC
2020	46	1.5	185	41	5	8.3	26	26	ABC

[1] 8 = August
[2] Average standardised nitrate concentrations with the same letters do not clearly differ from each other.

Table B4.12 Average nitrate concentration (mg/l), measured and corrected for weather conditions and variation in sampling population, in the water leaching from the root zone on farms participating in the derogation monitoring network in Sand-230; in addition, the average relative groundwater recharge, the groundwater level, the percentages of wetland and dry soils, the average month of sampling, and the differences between the years in standardised concentrations are presented.

Sand-230									
Year	**Number of farms**	**Relative groundwater recharge**	**Groundwater level (cm below surface level)**	**Wetland soils (%)**	**Dry soils (%)**	**Average sampling month[1]**	**Nitrate measured**	**Nitrate standard**	**Difference[2]**
2007	96	1.5	126	8	12	9.4	70	70	F
2008	96	1.2	139	8	12	8.6	55	63	EF
2009	94	1.2	151	8	12	8.7	51	56	DE
2010	94	1.6	133	8	11	8.7	62	61	EF
2011	95	1.7	137	8	12	8.5	47	46	BC
2012	94	1.4	140	8	12	8.5	43	44	BC
2013	101	1.4	148	7	14	8.8	46	46	BC
2014	105	1.5	138	7	14	8.7	51	48	CD
2015	109	1.4	133	8	14	8.7	45	45	BC
2016	112	1.3	126	9	13	9.0	37	39	AB
2017	114	1.2	169	8	14	9.2	32	33	A
2018	108	1.5	175	8	14	8.8	41	39	AB
2019	106	1.5	184	9	14	8.6	49	44	BC
2020	111	1.9	176	10	14	8.6	63	57	DE

[1] 8 = August.
[2] Average standardised nitrate concentrations with the same letters do not clearly differ from each other.

Table B4.13 Average nitrate concentration (mg/l), measured and corrected for weather conditions and variation in sampling population, in the water leaching from the root zone on farms participating in the derogation monitoring network in the Clay Region; in addition, the average relative groundwater recharge, the groundwater level, the drains discharge, the average month of sampling, and the differences between the years in standardised concentrations are presented.*

Clay Region								
Year	**Number of farms**	**Relative groundwater recharge**	**Groundwater level (cm below surface level)**	**Drains discharge (l/min)**	**Sampling month[1]**	**Nitrate**		**Difference[2]**
						measured	**standard**	
2007	60	1.5	91	0.90	5.8	24	24	DE
2008	64	1.1	97	0.77	5.2	16	21	CD
2009	64	1.1	86	0.80	5.0	14	19	BCD
2010	64	1.4	78	0.66	5.8	19	23	DE
2011	63	1.6	88	0.73	4.5	14	17	BC
2012	59	1.5	113	0.75	4.9	11	16	B
2013	66	1.2	98	0.83	4.5	11	13	A
2014	60	1.3	117	0.91	4.4	15	16	B
2015	60	1.3	105	0.86	5.1	22	20	CD
2016	60	1.3	100	1.02	4.7	13	13	A
2017	60	1.2	118	0.74	5.4	16	17	BC
2018	56	1.4	140	0.78	4.6	14	15	AB
2019	54	1.5	161	0.67	5.7	42	34	F
2020	56	1.8	122	0.88	5.0	37	28	EF

[1] 4= December

[2] Average standardised nitrate concentrations with the same letters do not clearly differ from each other.

Appendix 5 Comparison of data on fertiliser usage at derogation farms as calculated by Netherlands Enterprise Agency (RVO) and LMM

B5.1 Introduction

Since 2006, the Netherlands Enterprise Agency (RVO), formerly known as the National Service for the Implementation of Regulations (DR), as well as the Minerals Policy Monitoring Programme (LMM) have reported the calculated fertiliser usage on farms participating in the derogation monitoring network. Because the calculated data sometimes showed significant discrepancies in the past, Wageningen Economic Research has analysed these differences since 2010 at the request of the Ministry of Agriculture, Nature and Food Quality.

One important cause of the calculated differences between the LMM data and the RVO data is related to the different purposes for which fertiliser usage on derogation farms is calculated. The LMM calculations are aimed at calculating the fertilisation rates as accurately as possible, using as much farm-specific information as possible. The fertiliser usage calculations performed by RVO serve a different purpose, namely to discover 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 data concern all farms included in the Agricultural Census that have applied for derogation.

This Appendix compares the fertiliser usage as calculated based on LMM data and stated in this report, with the fertiliser usage as calculated by RVO (see Table B5.1). In addition, an explanation is provided of any differences that were found.

Table B5.1 Fertiliser usage in kg/ha on farms to which derogation has been granted according to RVO data, fertiliser usage in kg/ha on farms according to LMM derogation monitoring results, and differences between these source data in 2019 for both nitrogen and phosphate in kg/ha and in percentages

Item	LMM (kg/ha)	RVO (kg/ha)	Difference between LLM and RVO (basis) (kg/ha)	(%)
Nitrogen				
Livestock manure	230	235	-5	-2
Inorganic fertilisers	126	128	-2	-2
other organic fertilisers	1	2	-0.4	-25
Total	357	364	-7	-2
Fosfaat				
Livestock manure	72	73	-1	-1
Inorganic fertilisers	0	0	0	0
other organic fertilisers	1	1	0	1
Total	73	73	0	0

Source: based on data from RVO and FADN processed by Wageningen Economic Research

B5.2 Approach

The LMM population includes only farms that meet the following criteria:

- Fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals. This also applies to total fertilisation (i.e. inorganic fertilisers + livestock manure +
  other organic fertilisers). The relevant criteria are specified in Appendix 2 (Table B2.1).
- The farm records for the year concerned need to be worked out in detail (that was not possible for 3 farms in 2019).
- Farms may not have an anaerobic digestion plant.
- Farms must actually make use of the derogation in the year concerned (2 farms in the derogation monitoring network did not do so in 2019).

The application of these exclusion criteria meant that the number of LMM farms usable for derogation monitoring purposes in 2019 decreased from 300 to 279.

The following data sources were used to compare the RVO.nl and LMM figures for 2019:

- Farm Accountancy Data Network (FADN) of Wageningen Economic Research: this concerns the 300 farms that qualified for derogation monitoring (DMN) in 2019. We mainly analysed the fertilisation data, but also used other FADN data pertaining to these farms where necessary. 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 provided by the Netherlands Enterprise Agency (RVO.nl): this concerns 18,001 registration numbers (BRS numbers) of farms that applied for derogation in 2019.

B5.3 Analysis of differences

B5.3.1 Use of nitrogen in livestock manure

The calculated quantity of nitrogen in livestock manure is 5.0 kg per hectare lower according to the LMM data than according to the RVO data (see Table B5.1). Table B5.2 summarises the reasons for these differences.

Differences between the two populations are one cause of the discrepancies. If the RVO population were to be rendered comparable to the LMM population, the nitrate use in livestock manure calculated by RVO would increase by 2.5 kg (B in table B5.2) to 238 kg N/ha (rounded off). For this purpose, farms smaller than 10 hectare and/or 25,000 SO units have been excluded from the RVO.nl data set in accordance with the LMM population. In addition, the same confidence intervals have been used for the fertiliser quantities as in the LMM data set (see Appendix 2, Table B2.1). For this purpose, farms smaller than 10 ha and/or 25,000 SO units have been excluded from the RVO data set in accordance with the LMM population.
The remaining difference of -7.5 kg nitrogen per hectare (A-B in Table B5.2) may be attributed to the following factors (indicated by a to i):

a. The area of cultivated land in use on the above-mentioned 279 LMM farms exceeds the cultivated land area according to RVO data by approximately 1.05 ha. If the RVO results are converted to the area of cultivated land according to LMM data, we get a difference of 4.6 kg N/ha.
b. and c. In addition, the stocks, inputs and outputs registered in the LMM programme sometimes differ from the RVO 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 2019 was that the calculated LMM fertiliser quantities are 11.4 kg N/ha lower than the RVO quantities.
c. The remaining difference (0.2 kg nitrogen per hectare; items d through h) can be accounted for by differences in the method used to calculate excretion quantities. The BEX method is used for 58% of the farms participating in the LMM programme. As a result, the use of livestock manure according to the LMM data is 8.8 kg N per hectare less than according to the RVO data. The BEX method is applied in the LMM programme for all farms that report that they use the BEX method, provided that sufficient reliable data are available.
d. The standard-based excretion in the LMM programme is determined with greater accuracy than in the RVO.nl data set. There are a various reasons for this. RVO.nl is not always able to calculate excretion by dairy cows due to insufficient data on milk supplies or urea levels.
e. Furthermore, the LMM programme takes the stable system into account when determining the standard quantities. Stable system data are not included in the RVO.nl data set, so the lower standard quantities for solid manure are selected in the case of young livestock.
f. In addition, RVO does not classify excretion by hobby animals as 'Excretion', but as 'Other organic fertilisers'.

g. Furthermore, the excretion by intensive livestock is calculated differently, e.g. due to differences in the initial and closing stocks.

Table B5.2 Breakdown of differences in the use of nitrogen in livestock manure on derogation farms according to RVO data and according to LMM data for the year 2019

Item	**Nitrogen kg N/ha**
Difference between LMM and RVO.nl data (A)	-5.0
Difference due to different populations (B)	2.5
Difference in comparable populations (A-B)	-7.5
The difference (A-B) is caused by:	
a. Difference in acreage of cultivated land	4.6
b. Stocks	-4.1
c. Inputs and outputs	-7.3
d. Use of BEX* method in LMM programme	-8.8
e. Standard-based excretion by dairy cows	-0.7
f. Standard-based excretion by other cattle	0.7
g. Standard-based excretion by other grazing animals	2.1
h. Standard-based excretion by intensive livestock	6.0

Source: based on data from RVO and FADN processed by Wageningen Economic Research.
* The abbreviation BEX stands for Farm-Specific Excretion (National Service for the Implementation of Regulations, 2010).

B5.3.2 *Nitrogen in inorganic fertilisers and other organic fertilisers*

The differences observed in the application of nitrogen from inorganic fertilisers and other organic fertilisers between both datasets are limited in comparison to the differences with regard to nitrogen from livestock manure and can be attributed to the fact that the numbers in Table B5.1 do not apply to completely comparable populations (this is also one of the factors behind the differences in the application of nitrogen from livestock manure: see above explanation in section B5.3.1).

B5.3.3 *Phosphate in livestock manure, inorganic fertilisers and other organic fertilisers*

The nitrogen-phosphate ratio in cattle manure is reasonably stable. The limited differences between the LMM and RVO datasets for the application of phosphate from livestock manure are therefore caused by practically the same factors as for the application of nitrogen from livestock manure (as described above in section B5.3.1).
In the case of phosphate in inorganic fertilisers, there is no difference in the number of kilogrammes stated in Table B5.1. The use is also very small: 0.2 kg phosphate per hectare. Derogation farms are not permitted to use phosphate from inorganic fertilisers. LMM farms with more than one BRS number will have at least one BRS number with derogation, whereas the other BRS number or numbers will not be part of the derogation network; on the latter numbers, the use of phosphate from inorganic fertilisers is permitted if they are not part of the derogation network.

B5.4 Conclusion

The differences found do not give cause to adjust the LMM calculation method. This applies to nitrogen as well as phosphate.

References

Rijksdienst voor Ondernemend Nederland (RVO) (2020). Handreiking bedrijfsspecifieke excretie melkvee 2020. Den Haag, Rijksdienst voor Ondernemend Nederland.

Nederlandse Voedsel- en Waren Autoriteit (NVWA) (2020). Derogatie: inspectieresultaten mest 2019. Den Haag, Ministerie van Landbouw, Natuur en Voedselkwaliteit (LNV), Nederlandse Voedsel- en Waren Autoriteit.

Appendix 6 Background information on the weighting of results for agricultural practices and water quality

B6.1 Introduction

B6.1.1 Water quality

The water quality measurements for the derogation monitoring network (DMN) carried out by RIVM are not weighted. The structure of the data and possible weighting methods differ compared to the agricultural practice. For example, there is no water quality data available from the regular Farm Accountancy Data Network (FADN) or the Agricultural Census, which is available from certain agricultural practice data. However, consideration was given to whether weighting on the basis of acreage per LMM district would have an effect on the water quality results. It turned out that a weighting on the basis of acreage has practically no effect on the average nutrient concentrations, as the farms are already evenly distributed over the LMM districts in proportion to the acreage. It was therefore decided not to weight the water quality measurements in this report.

B6.1.2 Agricultural practices

The Farm Accountancy Data Network (FADN) of Wageningen Economic Research is comprised of farms for the Farm Accountancy Data Network (FADN) of the European Commission and a number of additional farms for various projects. The latter consist primarily of additional farms for the Minerals Policy Monitoring Program (LMM). The FADN comprises farms sampled from the Agricultural Census as well as a small number of farms that were selected for specific projects (such as the Koeien&Kansen (Cows and Opportunities) project).

The Agricultural Census includes all agricultural and horticultural farms in the Netherlands and a limited dataset. The FADN consists only of a sample of farms and therefore contains a much smaller number of farms, but a much more extensive set of data per farm is registered in the FADN. All the data for the farms in the FADN are also available in the Agricultural Census, so that key figures such as numbers of animals and surface areas in the Agricultural Census and the FADN can be compared to each other.

In the derogation monitoring network (e.g. in this report), a group of almost 300 sample farms from the LMM program is also available. This group is representative of the so-called derogation sampling population, which consists of farms that have also applied for derogation, have a minimum acreage of 10 ha under cultivation, and an economic size of at least 25,000 euros of Standard Output (SO).

Table B6.1 (Table 2.7 from the previous derogation report; Lukacs *et al.*, 2020) presents unweighted averages for the DMN farms and for the corresponding regions in the Agricultural Census (both datasets for 2018) whereby the surface areas are coloured yellow. The surface areas calculated for the DMN are consistently higher than the surface areas from the Agricultural Census.

Table 2.8 from the previous derogation report also indicates differences (see Table B6.2), particularly with regard to the milk production per farm as well as the milk production per hectare, which are coloured yellow: here unweighted DMN results are shown next to weighted results from the Farm Accountancy Data Network (FADN: the sample of farms for which the Netherlands reports to the European Commission). For the FADN, farms are stratified on the basis of type and size (in SO); like the DMN farm sample, the FADN farm sample is disproportional (i.e. not every farm has the same chance of being sampled) in order to minimise the standard error of the results, but this disproportionality makes it necessary to apply weighting (Roskam et al, 2020).

Table B6.1 Table 2.7 from 2020 derogation report (Lukacs et al., 2020). Overview of a number of general farm characteristics in 2018 of farms participating in the derogation monitoring network (DMN), compared to average values for the Agricultural Census (AC) sample population. The surface areas, which are consistently higher than in the DMN, are marked in yellow for purposes of clarity.

Farm characteristics[1]	**Population**	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
		250	**230**				
Number of farms in DMN	DMN	48	105	20	59	59	291
Grassland area (hectares)	DMN	61	41	42	59	63	52
	AC	50	33	34	49	46	43
Area used to cultivate silage maize (hectares)	DM	12	7.7	7.0	6.5	5.0	7.7
	AC	7.9	6.1	6.2	4.7	3.8	5.5
Other arable land (hectares)	DMN	2.2	1.6	2.4	1.6	2.2	1.7
	AC	0.4	0.4	1.2	0.9	0.3	0.5
Total area of cultivated land (hectares)	DMN	74	50	52	67	71	62
	AC	59	40	42	55	50	49
Percentage of grassland	DMN	83	84	85	89	93	87
	AC	87	84	81	91	93	88
Natural habitats (hectares)	DMN	2.4	0.4	0.6	3.3	2.7	1.8
	AC	0.4	0.2	0.9	0.4	0.4	0.3
Grazing livestock density (Phosphate LSUs/ per hectare) [2]	DMN	2.1	2.7	2.2	2.3	2.2	2.4
	AC	2.0	2.5	2.4	2.2	2.1	2.3
Percentage of intensive livestock farms	DMN	4.2	11	0.0	1.7	5.1	5.8
	AC	1.4	7.9	1.9	2.2	2.5	4.4
Grazing livestock density (Phosphate LSUs/ha)[2]							
Dairy cattle (including young livestock) (Phosphate LSUs/ per hectare)[2]	DMN	2.0	2.3	2.1	2.1	2.0	2.2
Other grazing livestock (Phosphate LSUs/ per hectare)[2]	DMN	0.1	0.3	0.1	0.2	0.2	0.2
Intensive livestock (total) (Phosphate LSUs per hectare)[2]	DMN	0.3	0.9	0.0	0.1	0.1	0.4
All animals (Phosphate LSUs/ per hectare)[2]	DMN	2.3	3.6	2.2	2.4	2.3	2.8

Source: CBS Agricultural Census 2018, processed by Wageningen Economic Research and FADN.

[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, 2000). The standard phosphate production of one dairy cow is equivalent to one Phosphate Livestock Unit.

Table B6.2 Table 2.8 from 2020 derogation report (Lukacs et al., 2020). Average milk production and grazing periods on dairy farms participating in the derogation monitoring network (DMN) in 2018, compared to the weighted average for dairy farms in the national FADN sample

Farm characteristic	Population	Sand		Loess	Clay	Peat	Total
		250	230				
Number of farms in DMN	DMN	46	89	17	53	50	255
kg FPCM[1]/farm (x1,000 kg)	DMN	1,226	1,110	963	1,243	1,311	1,188
	FADN	1,030	897		1,087	893	957
kg FPCM[1]per hectare of fodder crop	DMN	16,500	20,500	17,300	18,200	16,700	18,300
	FADN	16,600	19,700		17,500	16,000	17,800
FPCM production in kg[1] per dairy cow	DMN	9,400	9,700	9,500	9,300	8,900	9,400
	FADN	9,700	9,700		9,500	8,900	9,500
Percentage of farms with grazing in May-October period	DMN	89	82	88	81	88	85
	FADN	81	84		81	83	82
Percentage of farms with grazing in May-June period	DMN	89	82	88	81	88	85
	FADN	81	84		81	83	82
Percentage of farms with grazing in July-August period	DMN	89	78	88	81	86	83
	FADN	81	81		81	80	81
Percentage of farms with grazing in September-October period	DMN	85	76	88	77	76	79
	FADN	76	76		77	68	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% fat content and 3.32% protein content).

For the DMN, farms are stratified on the basis of:

- Derogation type: dairy farm or other type of farm according to the Dutch Standard Output (SO) classification (the SO classification is the Dutch variant of the European farm classification that is also based on the Standard Output). In this way, every company with agricultural activities is classified as a specific type of farm. This classification system has been in use since 2010 and has also been used retroactively for calculations in data files since 2000.
- LMM districts: Sand North (grouping of 3 LMM districts), Sand Central (grouping of 3 LMM districts), Sand South, Clay North, Clay Central, Clay South-west, River Clay, Peat North, Peat West, Loess (due to groupings for Sand North and Sand Central, only 10 instead of 14 LMM districts);
- Size in SO
  For each derogation type and LMM district, 3 class limits are defined with respect to size, which generates 4 different size classes per derogation type per LMM district. The farms are sorted on the basis of the number of hectares of cultivated land from small to large per derogation type and per LMM district. The class limits are then defined in such a manner as to ensure that the total number of hectares of land under cultivation in each of

the 4 size classes is as uniform as possible (per derogation type per LMM district). The number of sampled farms in the 4 classes is the same so that each sampled farm, within derogation type and LMM district, represents the same surface area.
In the population sample, this means that the number of farms in the classes with the smallest farms is clearly larger than the number in the classes containing the biggest farms.

The stratification results in 80 (2x10x4) strata. The 4 strata within a combination of derogation type and LMM district contain (practically) the same number of sampled farms. This results in relatively more big farms in the DMN sample of farms. In practice, the (preferential) selection from the FADN population of potential farms (so that fewer extra farms have to be recruited) also leads to unequal chances of being selected for the sample. In addition, the desired number of DMN farms per derogation type and per soil type (Table 2.2 in this report) results in some categories having a higher chance of being selected than others. Another complicating factor is that between 30 and 45 farms were not selected more or less randomly but were recruited directly from a specific project (Koeien&Kansen (K&K: Cows and Opportunities), Noordelijke Friese Wouden, Caring Dairy). This last number is slowly decreasing over the years: with the exception of K&K farms (up to and including 2019; in 2020, all K&K farms in the DMN were replaced), the participants in such projects stop participating at some point and are replaced by randomly selected farms in the same stratum.

There are also still DMN farms that participate in the so-called BES pilot. Farms in this pilot are allowed to apply more nitrogen from livestock manure than is indicated by the application standard for livestock manure as long as the nitrogen and phosphate application standards are not exceeded. Until now (5 farms in 2017 and 6 farms in 2018 and 2019), this involves only farms from the K&K project: For both years, it was decided not to include these 5 or 6 farms in calculating the results with regard to nutrient concentrations.

Considering all the above, it was decided to investigate whether a weighting method would provide average results that, with regard to the results in tables 2.7 and 2.8 of the derogation report (Table B6.1 and Table B6.2), are more in line with the Agricultural Census and the FADN, respectively. Reference values are not available for key figures on nutrients; for these results, consideration can be given to whether weighting would lead to smaller standard errors.
This same issue also exists within the regular FADN of the WEcR. There, stratification is done on the basis of NSO farm type and size (in SO). Due to a larger number of NSO farm types and up to 5 or 6 size classes per farm type, the number of FADN strata is approximately 125.

B6.2 Material and methods

B6.2.1 Material

A DMN subpopulation was put together from the Agricultural Census, referred to as the sample population. Farms in the sample population have:

- a minimum of 25,000 Dutch Standard Outputs (SOs);

- a minimum of 10 hectares of land under cultivation;
- no organic farming operations;
- a minimum of 60% of the land under cultivation is used as grassland;
- applied for derogation: If a farm has actually applied, it means that the two previous conditions (no organic farming operations and a minimum of 60% used as grassland) will rarely be of any consequence.

The farms in the sample population put together in this manner are divided into two types:

- Dairy farms: NSO type 4500;
- Other grassland farms.

In view of the stratification and desired numbers described above (Table 2.2 in this report), farms from the sample population are selected and approached to participate so that the strata contain the desired numbers of farms, to a total of 300 for the 80 strata (see section B6.1).
The data for these 300 farms is then registered as is done for all LMM farms, and nitrate concentrations as well as a number of other water parameters are measured.

The option to use derogation has existed since 2006. Although the most recent year available in FADN is 2019, data for calculating weighting factors via imputation (see next section) for 2019 were not available on time. Data over the 2006-2018 period was therefore used.

B6.2.2 Weighting methods

1. Until now, the results presented in the derogation reports were unweighted. Key figures were calculated per farm, and these were then averaged to provide regional and national results.
2. Farms in the derogation reports that also participate in the FADN in order to provide results for the European Commission are given weighting factors as a result. These are based on the stratification for the FADN mentioned previously, which differs from the stratification for the DMN. Accordingly, this method is not discussed further here. It is actually a type of retroactive stratification, among other reasons because a farm may be of a different size or type when selected than when the data is actually processed.
3. Retroactive stratification of the LMM farms in the DMN based on the stratification described previously for the DMN. The weighting factors are calculated in relation to the DMN sample population.
4. Weighting factors can be calculated via the nearest neighbour imputation method. Wageningen Economic Research has implemented this method in the STARS programme (Vrolijk et al, 2005). The 4 DMN farms from the maximum of 300 farms that most resemble a farm from the sample population are given a weighting for the farm from the sample population such that the sum of the 4 weightings is equal to 1. Each DMN farm is therefore given a number of weightings as the DMN farm will be linked to several farms from the sample population. The weightings per DMN farm are added together to calculate a weighting factor.

The degree of similarity between a DMN farm and a farm in the sample population is based on a number of variables that are known for the DMN farms as well as for the farms in the sample population, the so-called imputation variables. The following imputation variables were used in this study:

- Farm type: dairy farm or other grassland farm;
- LMM district: sand, clay, peat, or loess;
- Number of SO per farm;
- Number of SOs per hectare of cultivated land;
- Percentage of grassland in the cultivated land;
- The number of young livestock phosphate LSUs per dairy cow;
- Share of intensive livestock phosphate LSUs in the total number of phosphate LSUs;
- Distance as the crow flies;
- Share of soil type (sand, clay, peat, loess): each soil type share counts for 0.25.

STARS was also used in the two most recent Nitrate guideline reports (Fraters et al. (2016), Fraters et al. (2020), Chapter 2) and is used to calculate LMM key figures for arable farms and dairy farms on the Agrimatie website of WEcR. However, the exact method of imputation differs: in Fraters et al. (2016), Fraters et al. (2020) and on the Agrimatie website, the 3 most similar farms are used. According to Vrolijk et al. (2005), the underestimation of the variance decreases as the number of similar farms used increases, but it is not clear what exactly a sufficient number is. In addition, in the publications referred to above, a larger number of farms from the FADN was used, namely all farms that fall within the limits of the sample population for the Basic Monitoring Network. Some of the imputation variables used also differed and/or the importance attached to the different imputation variables also differed.

5. An unweighted average value is calculated per LMM district and per farm type (see method/point 1). These averages are then weighted based on the hectares of cultivated land in the relevant combinations of LMM district and farm type. RIVM has published an article on this method with regard to arable farms in the basic monitoring network in the sand areas (Fraters, 2019).

In the article, methods 1, 3, 4, and 5 are compared to each other in terms of average values and the standard errors of these averages on the basis of the following aspects:

- The average value for the DMN sample should be as close as possible to the average value for the sample population: this is possible only for key figures that are available for the sample population, such as the key figures in Table 2.7 of the derogation report mentioned previously (see Table B6.1).
- For a few other key figures that are relatively strongly related to the data available for the sample population but are not themselves specifically available in the sample population, a result that resembles the average value from the FADN is considered better. The table mentioned above (Table 2.8) from the derogation report is an example of this (see Table B6.2).

- In particular for the key figures that are not available in the sample population (which form the majority), consideration is given to the standard error of the average: a smaller standard error is assessed positively.
- To make the report easier to read and understand, preference is given to the use of a single weighting method for all key figures in the derogation report. That has always been the case until now, namely no weighting at all (method 1).

The calculations were carried out using statistics package R, version 4.0.2. For method 4, the imputation was carried out using the STARS computer program of Wageningen Economic Research (Vrolijk et al., 2005).

B6.2.3 *Points for attention*

a. Each year, some or all of the key figures for a number of farms are not usable because:
    1. The derogation was not used;
    2. The sampling by RIVM failed;
    3. The administrative record keeping by WEcR failed;
    4. The administrative records were kept by WEcR, but one or more key nutrient figures are such extreme outliers (limits indicated in Appendix 2 of this derogation report) that the key nutrient figures for these farms were not included.

Farms under (1) are all excluded. With regard to (2), (3) and (4), various options are possible:

- Including only those farms where sampling succeeded and where the key nutrient figures fall within the specified limits (the latter implies that the record keeping was successful). Farm operations and water quality then have the same weighting, but the number of DMN farms available is also the smallest.
- For the farm structure and farm operations, the DMN farms are used where the administrative records can be registered. For the key nutrient figures, the DMN farms are used where the key nutrient figures fall within the specified limits. For the water quality, the farms are used where sampling was successful. This is what is now being done in practice. It means that data from more DMN farms can be used, but the weighting factors for farm operations and water quality will then not be the same. If weighting is done in line with methods 3, 4, and 5, weighting factors will then have to be calculated three times, so that the above choice would require more computation. As explained at the beginning of this appendix, RIVM has decided to not yet apply any weighting for water quality in the derogation reports.

b. A number of DMN farms have not been randomly selected (e.g. from the K&K project)
    1. These farms are not given a weighting factor, i.e. are given a weighting factor of 0, and are not included in calculating the average values in all the methods. These farms also have a weighting factor of 0 for the FADN.
    2. These farms are given a weighting factor of 1, as they do exist, also in the sample population: they therefore only represent

themselves. This means that their results are taken into account only to a very limited degree in the weighted averages according to methods 3 and 4. However, their results count just as heavily as the results of the other DMN farms when it comes to the unweighted averages (methods 1 and 5).

c. For method 3, retroactive stratification, a minimum of 2 sample farms per stratum is required; otherwise it is not possible to calculate a standard error for the stratum. For a maximum of 300 available DMN farms and 80 strata, some strata will contain zero or only one DMN farm. This applies in particular to the other grassland farms in the Clay, Loess, and Peat regions. In such cases, strata have to be aggregated over all the years (at present 2006 up to and including 2018) so that each stratum contains a minimum of two DMN farms. There is not yet any protocol or procedure for doing so. At present, strata that at first sight look similar are grouped together. The number of strata then decreases to approximately 35 (depending, among other aspects, on whether the farms not chosen at random are given a weighting factor of 0 (making them not available) or a weighting factor of 1 (making them available).

This issue can also play a role in the regular FADN programme for the European Commission, so that strata are also aggregated. In the annual reports accounting for the FADN sample population (e.g. Roskam et al., 2020), a number of size classes per farm type were defined, which serve as the strata for the FADN. The Neyman allocation method is used to generate the optimum distribution of farms over the strata. Rules of thumb apply for the minimum and maximum number of farms per stratum. Farms are redistributed in order to meet these requirements, so that the distribution with the smallest standard error is chosen.

In method 3, the first step is to merge neighbouring size classes with each other. If there are then still strata with less than 2 farms remaining, regions are aggregated. If that is still insufficient, then farm types are aggregated.

B6.3 Results

In methods 3 (weighted in accordance with DMN stratification) and 4 (weighted with STARS weighting factors), farms not selected at random are given a weighting of 1.
Table B6.3 presents the average values and standard errors for the areas of cultivated land of DMN farms over the 2006-2018 period for various weighting methods for the entire Netherlands.

Table B6.3 Average values (Avg.) and standard errors (SE) for the areas of cultivated land of DMN farms over the 2006-2018 period for various weighting methods for the entire Netherlands

Year	**Agri-cultural Census**	**Unweighted (1)**		**Weighting according to DMN stratification (3)**		**Weighting with STARS weighting factors (4)**		**Weighting with areas per LMM soil type region (5)**	
	Avg.	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**
2006	41.10	48.60	1.564	41.65	1.003	39.43	1.292	48.32	1.688
2007	41.84	49.71	1.604	42.19	1.085	39.82	1.310	49.30	1.691
2008	43.35	51.25	1.790	42.22	1.039	41.18	1.430	51.34	1.883
2009	44.10	52.35	1.856	43.41	0.948	41.56	1.395	52.26	1.964
2010	43.73	52.43	1.850	43.58	0.940	41.95	1.465	52.58	1.959
2011	44.59	52.91	1.881	44.08	0.953	42.62	1.512	53.18	2.020
2012	45.21	55.42	1.949	45.52	1.040	44.48	1.584	56.25	2.101
2013	45.42	55.59	1.969	46.00	1.121	44.56	1.621	57.26	2.115
2014	46.39	56.37	1.999	47.69	1.156	44.49	1.694	58.67	2.141
2015	47.31	57.93	2.041	47.95	1.229	45.63	1.613	59.61	2.160
2016	48.76	60.07	2.133	49.77	1.194	48.34	1.680	63.05	2.347
2017	48.41	60.76	2.249	50.47	1.337	48.31	1.822	63.33	2.418
2018	48.96	61.79	2.249	51.98	1.352	50.54	1.947	64.56	2.512
Avg. ’06-‘18	45.32	55.01	1.933	45.88	1.108	44.07	1.566	56.13	2.077

Table B6.3 shows that:

- the areas of cultivated land calculated using DMN stratification weighting factors are the closest to the areas in the Agricultural Census: the average difference over the 13 years is 0.56 ha. Weighting with STARS weighting factors results in a somewhat larger difference: 1.25 ha.
- However, over the last three years, the areas calculated with the STARS weighting factors are closer to the figures in the Agricultural Census than the areas calculated using the DMN stratification.
- Using unweighted figures or weighting on the basis of areas per LMM soil type region results in much larger differences: 10 to 11 ha.
- Standard errors are the smallest with weighting in accordance with DMN stratification, followed by weighting with STARS weighting factors, followed by no weighting, and the largest when weighting with areas per LMM soil type region.

Tables B6.4 up to and including B6.8 present the averages and standard errors of the area of land cultivated for DMN farms over the 2006-2018 period calculated with the different weighting methods for the various soil type regions. LMM has four soil type regions: Sand, Clay, Peat, and Loess. Since 2014, the Sand Region has been subdivided into Sand-230 (the Sand region found in the provinces of Overijssel, Gelderland, Utrecht, Noord-Brabant and Limburg) and Sand-250 (the Sand region found in the other provinces). This subdivision has been implemented retroactively from 2006 onwards.

Table B6.4 Average values (Avg.) and standard errors (SE) for the areas of cultivated land of DMN farms over the 2006-2018 period for various weighting methods: Sand-250 soil type region

Year	**Agri-cultural Census**	**Unweighted (1)**		**Weighting according to DMN stratification (3)**		**Weighting with STARS weighting factors (4)**		**Weighting with areas per LMM soil type region (5)**	
	Avg.	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**
2006	50.37	53.35	3.511	48.89	2.918	47.90	3.579	51.70	3.680
2007	51.05	56.45	3.956	50.39	3.360	48.08	3.418	55.89	3.988
2008	52.95	59.02	4.456	49.59	2.959	48.52	3.666	58.18	4.349
2009	53.83	60.94	4.566	52.00	2.892	51.73	4.185	59.66	4.484
2010	53.65	63.12	4.766	52.97	2.934	52.11	3.995	61.99	4.731
2011	54.09	60.94	4.697	51.01	2.896	53.41	4.194	59.53	4.543
2012	55.40	64.28	4.722	53.82	2.740	58.63	3.840	63.25	4.563
2013	55.63	66.04	5.473	55.08	2.972	56.46	4.266	64.25	5.140
2014	56.01	67.16	6.150	54.39	2.773	54.63	4.790	65.70	5.716
2015	57.47	69.84	5.853	53.81	2.534	54.72	3.746	69.29	5.757
2016	59.58	73.01	6.115	56.72	2.590	59.38	4.317	72.22	5.975
2017	58.71	72.23	6.081	59.15	2.845	60.08	4.338	71.53	6.130
2018	58.92	71.54	6.195	61.77	3.100	59.17	3.983	71.28	6.407
Avg. ’06-’18	55.21	64.46	5.119	53.81	2.886	54.22	4.024	63.42	5.036

Table B6.5 Average values (Avg.) and standard errors (SE) for the areas of cultivated land of DMN farms over the 2006-2018 period for various weighting methods: Sand-230 soil type region

Year	**Agri-cultural Census**	**Unweighted (1)**		**Weighting according to DMN stratification (3)**		**Weighting with STARS weighting factors (4)**		**Weighting with areas per LMM soil type region (5)**	
	Avg.	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**
2006	33.83	38.56	2.012	35.26	1.219	33.16	1.658	39.36	2.020
2007	34.44	38.42	1.987	35.22	1.293	32.71	1.669	38.88	1.955
2008	35.36	38.64	2.054	33.94	1.290	33.71	1.898	38.88	2.048
2009	35.91	38.94	2.074	36.06	1.276	33.64	1.775	39.61	2.014
2010	35.85	39.68	2.205	35.38	1.274	34.22	1.832	40.39	2.117
2011	36.65	41.92	2.373	37.20	1.336	34.88	1.913	42.28	2.309
2012	37.22	44.20	2.572	37.89	1.415	36.49	1.966	44.43	2.527
2013	37.37	44.85	2.441	38.00	1.269	36.49	2.021	45.28	2.405
2014	37.79	45.98	2.400	39.19	1.351	36.11	2.202	46.40	2.440
2015	38.60	46.81	2.504	38.99	1.207	38.24	2.226	47.57	2.512
2016	39.54	47.91	2.453	40.73	1.213	39.62	2.202	49.14	2.483
2017	39.64	48.09	2.583	40.32	1.241	39.34	2.309	49.17	2.589
2018	40.24	50.74	2.793	43.05	1.473	42.49	2.622	51.66	2.788
Avg. ’06-’18	37.11	43.44	2.342	37.79	1.297	36.24	2.022	44.08	2.323

Table B6.6 Average values (Avg.) and standard errors (SE) for the areas of cultivated land of DMN farms over the 2006-2018 period for various weighting methods: Loess soil type region

Year	Agri-cultural Census	Unweighted (1)		Weighting according to DMN stratification (3)		Weighting with STARS weighting factors (4)		Weighting with areas per LMM soil type region (5)	
	Avg.	Avg.	SE	Avg.	SE	Avg.	SE	Avg.	SE
2006	39.18	48.07	4.880	45.05	2.391	43.11	7.237	43.79	6.563
2007	38.10	50.13	5.107	44.82	2.867	50.64	6.497	50.14	5.323
2008	38.97	49.70	5.540	43.78	3.642	48.17	5.683	49.93	5.293
2009	39.05	47.68	4.366	43.56	3.204	42.83	4.691	47.66	4.368
2010	39.28	45.47	4.287	44.04	2.580	41.02	4.454	44.76	4.332
2011	40.60	46.11	4.449	42.37	1.791	40.54	4.683	45.69	4.467
2012	39.79	43.88	4.298	42.85	2.409	41.95	4.482	43.50	4.279
2013	38.87	44.09	4.908	42.96	2.781	41.60	4.660	43.59	4.898
2014	39.49	46.02	5.239	38.69	3.895	43.16	4.601	46.84	5.256
2015	40.43	48.84	5.200	42.15	2.792	45.47	5.646	48.46	5.267
2016	41.51	51.77	5.660	47.98	3.319	46.63	6.510	51.53	5.701
2017	42.57	50.76	5.975	45.59	2.940	47.92	5.887	51.35	5.903
2018	42.06	51.59	6.352	46.04	3.394	49.79	6.014	52.56	6.341
Avg. ’06-’18	39.99	48.01	5.097	43.84	2.923	44.83	5.465	47.68	5.230

Table B6.7 Average values (Avg.) and standard errors (SE) for the areas of cultivated land of DMN farms over the 2006-2018 period for various weighting methods: Clay soil type region

Year	Agri-cultural Census	Unweighted (1)		Weighting according to DMN stratification (3)		Weighting with STARS weighting factors (4)		Weighting with areas per LMM soil type region (5)	
	Avg.	Avg.	SE	Avg.	SE	Avg.	SE	Avg.	SE
2006	46.43	54.27	3.452	46.74	2.361	44.29	2.698	53.87	3.519
2007	47.41	56.20	3.608	46.80	2.646	44.77	2.866	54.98	3.624
2008	49.40	57.80	4.103	48.45	2.236	46.64	3.102	57.46	4.004
2009	50.25	59.09	4.332	48.05	1.900	46.09	2.867	58.00	4.219
2010	49.64	58.72	4.322	48.43	1.713	45.82	3.364	58.29	4.288
2011	50.67	58.09	4.600	47.29	1.655	46.42	3.337	57.93	4.517
2012	51.03	60.34	4.716	48.91	2.090	48.39	3.520	60.29	4.609
2013	51.23	58.38	4.397	48.18	2.376	49.34	3.628	59.39	4.335
2014	52.64	58.92	4.169	52.01	2.778	50.08	3.313	61.69	4.197
2015	53.55	58.75	3.992	52.84	3.097	49.81	3.469	60.18	4.105
2016	55.76	62.96	4.583	54.20	3.074	54.09	3.507	65.53	4.681
2017	55.00	65.02	4.774	56.64	3.602	53.71	4.032	66.21	4.681
2018	55.39	66.68	5.049	55.73	3.470	55.73	4.453	67.39	5.055
Avg. ’06-’18	51.42	59.63	4.315	50.33	2.538	48.86	3.397	60.09	4.295

Table B6.8 Average values (Avg.) and standard errors (SE) for the areas of cultivated land of DMN farms over the 2006-2018 period for various weighting methods: Peat soil type region

Year	Agri-cultural Census	Unweighted (1)		Weighting according to DMN stratification (3)		Weighting with STARS weighting factors (4)		Weighting with areas per LMM soil type region (5)	
	Avg.	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**
2006	44.13	53.11	4.318	42.64	2.398	40.79	3.219	51.92	4.580
2007	44.93	52.77	3.917	44.59	2.458	41.72	2.789	52.63	3.986
2008	46.65	55.84	4.447	45.50	2.952	43.89	3.067	56.94	4.525
2009	47.31	58.64	4.687	46.00	2.454	45.30	3.037	58.09	4.898
2010	46.18	56.25	4.158	46.98	2.499	45.79	2.985	56.25	4.342
2011	47.04	58.47	4.350	48.98	2.817	46.92	2.973	58.82	4.474
2012	47.52	62.96	4.660	50.50	2.888	47.24	2.878	63.78	4.813
2013	47.54	65.92	4.962	52.89	3.464	46.64	3.082	67.84	5.298
2014	48.75	65.76	5.050	53.52	2.841	47.75	3.159	67.00	5.181
2015	49.57	68.80	5.493	54.36	3.163	48.35	3.212	69.79	5.530
2016	50.70	71.70	5.939	56.40	2.905	51.41	3.596	73.33	5.965
2017	49.88	72.02	6.427	54.89	2.891	51.25	3.735	73.83	6.423
2018	50.44	70.52	5.856	56.60	2.919	53.00	3.785	74.09	6.103
Avg. ’06-’18	47.74	62.52	4.943	50.30	2.819	46.93	3.194	63.41	5.086

The results for the various soil type regions (tables B6.4 up to and including B6.8) are, roughly speaking, the same as the results for the Netherlands as a whole (Table B6.3).

- For the Sand-230 Region, the Loess Region, and the Clay Region, weighting according to DMN stratification results in the smallest deviation from the Agricultural Census average as well as the smallest standard error.
- For the Sand-250 Region and the Peat Region, weighting with STARS weighting factors results in the smallest deviation from the Agricultural Census average and weighting according to DMN stratification results in the smallest standard error.
- Using unweighted figures and weighting on the basis of areas per LMM soil type region always result in larger deviations from the Agricultural Census average and larger standard errors than the other two methods.

If the farms not selected at random are given a weighting factor of 0 instead of being included (Table B6.3), then for the entire Netherlands:

- the averages over all the years are practically the same (0.01-0.02 ha difference) for all the methods except for using unweighted figures, in which case the average area of land under cultivation is 53.64 ha. If unweighted average figures are used over the 2006-2018 period, the farms not selected at random turn out to have 64.00 ha of cultivated land and the other farms 54.27 ha of cultivated land.
- If unweighted figures are used or if weighting is done with areas per LMM soil type region, the standard errors are 5% to 10%

larger, and if weighting is done with STARS weighting factors the standard errors remain practically the same. If weighting is done on the basis of DMN stratification, the standard errors are 5% smaller.

Roughly speaking, the results are the same for the separate soil type regions. The inclusion of farms not selected at random therefore results in a limited improvement with regard to the area of cultivated land per farm.

Table B6.9 presents the average values and standard errors for the nitrogen surplus on the soil surface balance in kg/ha for DMN farms over the 2006-2018 period for various weighting methods for the entire Netherlands.

Table B6.9 Average values (Avg.) and standard errors (SE) for the nitrogen surplus on the soil surface balance in kg/ha for DMN farms over the 2006-2018 period for various weighting methods for the entire Netherlands

Year	**Unweighted (1)**		**Weighting according to DMN stratification (3)**		**Weighting with STARS weighting factors (4)**		**Weighting with areas per LMM soil type region (5)**	
	Avg.	**SE**	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**
2006	195.8	5.29	198.7	5.93	199.6	6.97	194.1	5.90
2007	183.8	5.40	189.9	6.26	188.2	6.43	183.7	5.51
2008	177.1	4.52	181.0	4.92	182.5	5.88	179.4	4.56
2009	181.2	5.60	188.1	5.99	192.1	6.79	190.5	6.13
2010	178.2	4.98	183.4	5.14	182.7	6.29	181.8	4.86
2011	173.3	4.54	176.4	5.33	171.2	7.03	174.9	4.99
2012	177.8	4.43	178.7	5.62	178.3	5.93	181.6	4.78
2013	186.2	4.56	188.5	4.67	188.9	5.97	189.4	5.00
2014	153.6	5.04	158.6	5.97	155.9	6.15	159.7	5.63
2015	170.2	5.02	172.7	4.85	173.0	6.67	172.2	4.83
2016	170.0	4.75	170.4	5.27	166.2	5.38	172.3	6.97
2017	153.2	4.98	157.3	5.79	159.8	6.28	153.8	6.97
2018	186.6	4.75	188.3	5.02	184.0	5.45	186.4	5.27
Avg. ’06-’18	175.9	4.91	179.4	5.44	178.7	6.25	178.4	5.49

Table B6.9 shows that:
- the average values for the nitrogen soil surpluses over the years do not differ much, varying from 175.9 kg N per hectare to 179.4 kg N per hectare;
- using unweighted figures or weighting on the basis of areas per LMM soil type region results in lower nitrogen soil surpluses than the other two methods. The unweighted average nitrogen soil surplus over the 2006-2018 period for the farms not selected at random is 153.3 kg/ha; the corresponding figure for the other farms over the same period is 177.9 kg/ha. If unweighted figures are used or if weighting is done on the basis of areas per LMM soil type region, the farms not selected at random count more heavily than in the two other weighting methods. The farms not

selected at random participated in projects in which there was a great deal of emphasis on good nutrient management.
- If weighting is done on the basis of areas per LMM soil type region, the result calculated for the average area of cultivated land remains the same regardless of whether farms not selected at random were included or not, whereas there is a difference regarding the result calculated for the nitrogen soil surpluses. This is caused by the method of weighting on the basis of areas.
- The standard errors are the smallest when using unweighted figures, followed by weighting in accordance with DMN stratification, followed by weighting on the basis of areas per LMM soil type region, and the largest with STARS weighting factors.

Tables B6.10 up to and including B6.14 present the averages and standard errors for the nitrogen soil surplus in kg/ha for DMN farms over the 2006-2018 period for the various soil type regions using different weighting methods. The results for the various soil type regions are roughly the same as for the Netherlands as a whole, although the standard errors when weighting is done on the basis of DMN stratification are then often larger than when weighting is done on the basis of areas per LMM soil type region and sometimes the largest in the Sand-230 Region and in the Clay Region. When STARS weighting factors are used, the nitrogen soil surpluses in the Peat Region are somewhat more divergent than when the other methods are used.

Table B6.10 Average values (Avg.) and standard errors (SE) for the nitrogen surplus on the soil surface balance in kg/ha for DMN farms over the 2006-2018 period for various weighting methods: Sand-250 Region

Year	**Unweighted (1)**		**Weighting according to DMN stratification (3)**		**Weighting with STARS weighting factors (4)**		**Weighting with areas per LMM soil type region (5)**	
	Avg.	**SE**	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**
2006	163.4	8.93	163.4	12.13	167.6	11.83	154.8	12.26
2007	174.8	11.14	169.7	13.32	170.3	17.09	177.7	10.58
2008	164.9	8.19	166.9	8.36	159.1	7.64	160.7	6.74
2009	170.9	8.99	173.7	11.23	167.2	11.38	170.3	8.17
2010	157.4	9.79	165.6	12.45	148.2	8.71	158.7	9.40
2011	166.7	8.72	172.7	9.09	163.1	9.72	157.8	6.69
2012	165.1	9.32	165.3	11.24	153.6	11.43	165.8	8.41
2013	174.2	6.78	179.1	7.97	177.3	12.33	174.7	7.10
2014	134.1	9.08	143.0	7.69	123.2	11.18	138.9	7.46
2015	155.4	8.43	160.0	9.54	147.1	7.98	152.9	8.36
2016	150.2	7.91	153.7	7.56	148.4	8.56	151.7	7.50
2017	153.1	9.06	158.2	7.30	159.4	7.97	160.7	7.70
2018	154.4	10.18	151.6	9.06	148.5	12.03	150.6	8.46
Avg. ’06-’18	160.4	8.96	163.3	9.76	156.4	10.60	159.6	8.37

Table B6.11 Average values (Avg.) and standard errors (SE) for the nitrogen surplus on the soil surface balance in kg/ha for DMN farms over the 2006-2018 period for various weighting methods: Sand-230 Region

Year	**Unweighted (1)**		**Weighting according to DMN stratification (3)**		**Weighting with STARS weighting factors (4)**		**Weighting with areas per LMM soil type region (5)**	
	Avg.	**SE**	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**
2006	190.6	8.77	194.4	9.21	183.5	10.81	184.3	8.68
2007	169.3	10.31	176.4	10.67	176.0	11.06	162.0	10.34
2008	157.6	8.72	156.8	8.80	152.3	7.64	146.6	7.60
2009	155.7	10.88	153.8	8.52	146.8	9.23	151.4	7.33
2010	165.1	9.16	170.1	9.01	165.4	7.41	160.8	7.49
2011	153.1	7.28	152.3	8.90	145.4	9.34	150.8	8.36
2012	158.8	7.09	164.9	12.04	157.8	8.37	165.0	8.51
2013	168.4	6.17	167.5	6.84	162.6	6.52	164.7	6.06
2014	130.9	8.00	133.6	9.81	130.6	8.39	126.0	8.15
2015	151.9	10.56	160.1	9.12	164.4	14.51	148.0	10.65
2016	152.0	7.78	146.9	6.71	137.9	7.25	147.2	6.58
2017	129.4	7.91	132.9	7.98	127.1	7.20	122.2	8.06
2018	178.0	7.38	178.7	7.89	171.2	7.26	169.8	8.19
Avg. ’06-’18	158.5	8.46	160.7	8.89	155.5	8.85	153.8	8.15

Table B6.12 Average values (Avg.) and standard errors (SE) for the nitrogen surplus on the soil surface balance in kg/ha for DMN farms over the 2006-2018 period for various weighting methods: Loess Region

Year	**Unweighted (1)**		**Weighting according to DMN stratification (3)**		**Weighting with STARS weighting factors (4)**		**Weighting with areas per LMM soil type region (5)**	
	Avg.	**SE**	**Avg.**	**SE**	**Avg.**	**SE**	**Avg.**	**SE**
2006	136.0	16.68	126.1	17.22	124.7	16.78	125.3	15.46
2007	138.9	19.16	143.1	17.54	138.3	22.59	138.7	19.41
2008	141.5	9.94	145.8	6.21	144.4	8.61	144.0	6.75
2009	128.7	13.15	124.9	10.00	122.2	13.15	126.1	13.53
2010	154.1	13.28	156.0	8.81	178.9	18.30	160.1	14.82
2011	146.6	12.20	152.9	11.77	143.8	10.84	147.1	13.42
2012	151.9	16.40	142.1	13.93	154.6	19.58	151.9	16.15
2013	150.5	20.39	137.5	22.70	154.3	21.07	155.6	22.73
2014	122.0	17.19	130.5	15.99	125.8	15.03	122.3	16.21
2015	171.1	12.26	169.1	7.64	168.4	7.80	175.0	13.67
2016	173.1	11.13	171.9	8.77	177.2	8.96	178.5	11.93
2017	150.7	12.39	144.3	12.06	154.9	10.92	142.4	11.29
2018	175.7	13.39	174.3	9.97	183.3	14.28	180.8	14.35
Avg. ’06-’18	149.3	14.43	147.6	12.51	151.6	14.46	149.8	14.59

Table B6.13 Average values (Avg.) and standard errors (SE) for the nitrogen surplus on the soil surface balance in kg/ha for DMN farms over the 2006-2018 period for various weighting methods: Clay Region

Year	Unweighted (1)		Weighting according to DMN stratification (3)		Weighting with STARS weighting factors (4)		Weighting with areas per LMM soil type region (5)	
	Avg.	SE	Avg.	SE	Avg.	SE	Avg.	SE
2006	195.3	10.08	191.2	11.61	185.9	11.55	190.4	11.13
2007	179.0	10.02	190.5	12.53	175.3	9.92	178.2	10.01
2008	187.8	6.55	191.7	5.79	186.2	7.08	191.5	5.66
2009	195.4	11.08	205.4	12.48	209.1	9.10	201.5	12.57
2010	170.3	8.68	173.4	8.61	166.1	8.26	174.5	7.94
2011	164.5	8.52	173.0	8.90	154.0	12.67	167.8	8.28
2012	168.0	6.73	169.2	8.91	168.2	9.09	169.5	7.63
2013	180.9	9.34	183.1	9.41	183.2	11.63	185.7	9.64
2014	153.8	11.22	157.9	13.59	158.7	12.18	159.7	10.50
2015	161.5	8.32	161.9	9.15	158.8	10.31	169.9	7.99
2016	174.7	11.14	175.2	12.52	173.3	10.33	181.5	16.38
2017	151.3	10.99	154.7	13.11	166.2	13.74	147.6	16.24
2018	181.0	9.43	182.9	10.47	176.1	9.56	186.7	9.50
Avg. ’06-’18	174.1	9.39	177.7	10.54	173.9	10.42	177.3	10.27

Table B6.14 Average values (Avg.) and standard errors (SE) for the nitrogen surplus on the soil surface balance in kg/ha for DMN farms over the 2006-2018 period for various weighting methods: Peat Region

Year	Unweighted (1)		Weighting according to DMN stratification (3)		Weighting with STARS weighting factors (4)		Weighting with areas per LMM soil type region. (5)	
	Avg.	SE	Avg.	SE	Avg.	SE	Avg.	SE
2006	260.7	13.74	254.7	14.74	285.2	13.36	248.5	12.70
2007	238.7	11.35	234.0	12.43	251.7	11.99	228.2	11.14
2008	221.1	13.37	218.4	16.36	252.8	18.22	213.9	13.56
2009	237.6	13.32	237.9	14.66	268.3	14.03	236.8	12.59
2010	244.3	11.90	240.1	12.29	269.4	14.29	241.5	10.56
2011	232.8	11.83	228.0	15.10	251.8	15.27	230.9	11.74
2012	240.2	10.88	230.4	11.52	254.7	13.48	235.0	11.05
2013	243.9	12.58	239.5	11.71	257.0	13.76	236.6	12.59
2014	213.6	10.65	211.9	11.13	218.7	12.52	215.4	12.49
2015	219.9	10.25	218.8	10.18	232.5	11.71	218.2	8.47
2016	213.8	11.63	212.3	11.08	217.0	12.34	202.8	14.55
2017	195.4	13.45	199.3	13.03	204.1	13.92	191.5	12.50
2018	238.9	11.54	244.5	10.76	247.6	12.20	235.9	11.43
Avg. ’06-’18	230.9	12.04	228.4	12.69	247.0	13.62	225.8	11.95

The picture for the standard errors of other key nutrient figures, such as fertiliser application and crop yield, is the same as it is for the nitrogen soil surplus. The standard errors are generally the smallest when using unweighted figures, followed by weighting in accordance with DMN stratification, followed by weighting on the basis of areas per LMM soil type region, and the largest with STARS weighting factors.

B6.4 Conclusions

Based on the results presented above, the methods using unweighted figures and weighting on the basis of areas per LMM soil type region are eliminated. Although these methods yield slightly better results for the nitrogen soil surplus in kg/ha, the results that they provide for the area of cultivated land per farm diverge much more strongly from the Agricultural Census figures than the results provided by weighting on the basis of DMN stratification or weighting with STARS weighting factors.

Weighting on the basis of DMN stratification results in smaller standard errors than does weighting with STARS weighting factors for the area of cultivated land as well as for the nitrogen soil surplus in kg/ha. The divergence in the area of cultivated land from the Agricultural Census is also the smallest when weighting is done on the basis of DMN stratification. In view of the above results, the method of weighting on the basis of DMN stratification is chosen here.

In methods 3 (weighted in accordance with DMN stratification) and 4 (weighted with STARS weighting factors), farms not selected at random are given a weighting of 1. Including farms not selected at random does not really improve matters much when weighting is done either on the basis of DMN stratification or STARS weighting factors. However, the results also do not provide any grounds for leaving these farms out. If unweighted figures are used, the result for the average area of cultivated land does change substantially. If the farms not selected at random are not included, the standard errors increase if unweighted figures are used or if weighting is done on the basis of areas per LMM soil type region.

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