

**Author's response to interactive comments on "Management, regulation and environmental impacts of nitrogen fertilization in Northwestern Europe under the Nitrates Directive; a benchmark study" by H. J. M. van Grinsven et al.**

Dear Dr Reis, dear Stefan,

Please find below our point by point response to both review reports. We thank both reviewers for their thorough review and their useful suggestions. Reviewer #1 is critical about our paper and suggests some major changes. We think that these suggestions mostly are based on misunderstandings of this reviewer caused by unclear statements about the objectives and methods of our assessment. This has been further clarified now and we hope that the current manuscript is acceptable.

All changes in the manuscript have been marked, including minor changes suggested by the co-authors. Responses to reviewer #1 are marked in green to reviewer #2 in blue. Other changes are marked in yellow (changes made in the proof print of the Discussion paper also have been included but have not been marked). We hope this facilitates checking our response to the referee reports.

Best regards on behalf of all co-authors,

Hans van Grinsven

## Anonymous Referee #1

Received and published: 27 July 2012

In general we have copied adjusted text in our response. Furthermore we have marked adjustments following from review #1 in the manuscript in GREEN. Adjustments following from review #2 are marked in blue. Other adjustments are marked in yellow.

### General comments:

The Nitrates Directive is implemented differently in the countries in Northern Europe, yet the farming conditions are fairly similar. It is therefore very important to make comparisons in order to improve our knowledge on measures to reduce the impact of farming on nutrient losses to the environment. This paper includes a lot of valuable information. However, the paper needs focusing. It is not clear what the main purpose is: To compare the measures under the Nitrate Directive? To compare the effect of different measure? To compare monitoring or data collection? To calculate nitrogen balances? To validate the MITERRA Model? or To point out challenges for EU and the Member States as stated in the abstract? A clear purpose needs to be defined, and the following text and the title needs to be altered accordingly.

*Response. We thank the reviewer for the suggestions. Although we respect this opinion of the referee we do not agree to this overall conclusion of lack of focus and suggested consequence. The objectives of the paper are stated on P7357, L10-17. These objectives may be broad, but the authors believe that a broad, and integrated assessment is justified and necessary to provide a first and integrated overview of facts and figures of the implementation and effects of the NiD and to evaluate and benchmark it's working. We do realize that a full assessment on selected topics of the NiD requires a much more exhaustive effort, but view this paper as a possible starting point for such various, more focused comparisons.*

### Specific comments:

It seems as if the authors consider the MITERRA model as the most correct way of calculating the nitrogen balances, without addressing the validity of the large number of standard values in the model, e.g. the fractions stated in table 2, the way of calculating the manure excretion from animals and the calculation of N removal by crops.

*Reply. The authors are well aware of the limitations associated with models like MITERRA. For this assessment, MITERRA was the best documented tool available. We have further clarified the purpose of using MITERRA for the benchmark in 2.3. The model is described and validated in Velthof et al. 2008 and Lesschen et al. 2011, and favorably compares with other models (De Vries et al., 2011). This information was added to section 2.3. However, validation of MITERRA was not an objective in our study.*

It is suspicious that there are so large differences between MITERRA removals and the national estimates (table 12).

*Reply: Indeed differences are large, but by confronting national data and MITERRA results, we were able to make a critical assessment of both MITERRA and national data. The list of authors covers all countries in this study and we had intense debates among co-authors about causes of discrepancies between MITERRA results and data. This has led to adjustments of both MITERRA and some critical notes to officially reported national data.*

Reading the abstract and the manuscript one gets the impression that the main focus was intended to be the problems of calculating the nitrogen balances. If that is the case more documentation ought to be included. If that is not the case less attention should be directed towards the MITERRA model.

*Reply: the referee is not specific where this impression is based on. The abstract clearly states that it uses both models and national reports. It clearly states that we compared*

*implementation of the NiD and effects, and we present NiD impacts both on the nitrogen balance and water quality. But the impression is correct that the environmental effect was most apparent for the N balance, which was therefore somewhat emphasized in the abstract.*

The paper refers to specific measures but it is not always clear what are mandatory measures and what are efforts of the individual farmer. For example: the fertilizer equivalents (FE) stated in table 9 and mentioned at page 7364 are mandatory measures. But the authors go on and talk about various ways of improving the equivalencies at page 7365 – this has nothing to do with the mandatory requirements but are means for the farmer to improve the actual efficiency of the organic manure. Also concerning nitrogen standards for crops, the authors need to be more precise in terms of mandatory nitrogen standards and recommended standards.'

*Reply: We have made sure that in the revised text the term 'Standards' always refers to legally set N application levels. The referee is correct that in Table 9 we did not indicate if FE values have a legal status. This is now specified (they are legal (statutory) in all countries considered except France). We are not sure what the reviewer means by "Recommended standards": if this refers to fertilizer recommendations, and associated (default) FE values for N from manures, these of course have no legal status. We have made this more explicit in the text. Farmers have various options to meet legal application standards or FE values while maintaining yield levels; a few of which are mentioned. And although specific measures are indeed not mandatory in the NiD or action programs derived from it, it is the legalization of application limits and manure efficiencies which provide the incentive to farmers to take measures to improve nitrogen efficiencies.*

#### **Technical corrections:**

P.7356, I 23: 'most Member States have implemented four actions programs' – I am not sure that this is correct? And how is a 'new action program' defined – new goals, new measures, new evaluations?

*Reply: The reviewer is correct. Article 5, sub 6 of NiD states that "MS shall review and if necessary revise their action programmes ... at least every four year": therefore we changed L23 to: Since the introduction of the NiD in 1991, EU member states have implemented several action programs and have delivered several monitoring reports. (mostly four for the 7 countries in this benchmark)*

*As to the definition of new action programmes: The "new" indicates that it applies to a new (4-year-)period, and that in general it will contain new measures (when either the national government or the EU commission concludes that the effectiveness of the NiD should be improved). We have not adjusted the text as we think this meaning of "new" is fairly straightforward.*

P.7356, I 2: the reference ' Fraters et al.' – it sounds as if this reference is an EU study. This is not the case !!

*Reply: Indeed unclear and now corrected*

P.7360: The MITERRA removal is compared to national and EUROSTAT data. The other critical data component is animal manure, the paper would benefit from a similar comparison.

*Reply: Indeed manure production is another possible source of discrepancy, but less so than N removal. For the seven countries MITERRA excretion in 2008 on average is 7 kgN/ha higher than in EUROSTAT for 2005-2008 and more than for N-removal caused by comparing different years. The 7 kgN/ha can be deduced from data in Table 5 (Eurostat data more or less reflect the information in the national reports) and in Table 10. We have included this information in the revised manuscript). In section 4.2 (p7372 L28 to P7373 L13) we discuss in some detail the discrepancy between dairy excretion as in MITERRA and census data for Ireland P7372 L28 to P7373 L13, and for Brittany P7372, L16 as for these regions the discrepancy is largest. We do not think that adding a more*

*detailed comparison for production of gross input of animal manure (e.g. per livestock type) would improve the paper.*

P.7363, I 13: 'mostly apply to farms with at least 70-80% of farm land in use for grassland' - in Denmark the requirement is at least 70% of the area with roughage (fodder beet, grass or cereal /maize with catch crops).

*Reply: This information has now been added.*

p. 7365, I.26: 2nd and 3rd reporting period? At page 7358, I.8 the authors refer to the third reporting period with references from 2008.

*Reply: This is now corrected: as far as we know the 2008 reports refer to the fourth reporting period (covering effects of the third action program).*

P. 7367,

I 20-25: here artifacts are caused by differences between periods within countries,  
I. 25-27: here artifacts are caused by differences between countries. This could be clarified.

*Reply: L20-25 states that: differences "in the nitrate response" between periods (2000-2003 vs. 2004-2007) and "between" countries in part are artifacts of different monitoring procedures between countries and even sometimes between periods within one country. The sentence has been modified. L25-27 is about differences "in the nitrate response between countries", due to hydrogeochemical factors (which by no means are artifacts). This is now clarified.*

p. 7368, I. 15-19: how are the above mentioned artifacts dealt with in this overall picture stated here?

*Reply: In view of artifacts due to monitoring procedures and different hydrogeochemistry we have to restrict ourselves to these rather broad statements. This section is rewritten to: [Changes in monitoring procedures and densities do not allow solid conclusions on nitrate trends between the 3rd and 2nd reporting period based on the total dataset of groundwater observations. However, the overall picture appears to be that nitrate concentrations did not change between 2000 and 2007.]*

p. 7369, I. 7-10: the difference between MITERRA leaching and groundwater should be explained. Furthermore - Figure 7 – what type of water is this – leaching or ground water?

*Reply: Data in Figure 7 refer to leaching water – Caption is corrected. The difference between MITERRA and monitoring data is already explained in 7369 I10-12 and in the adjusted section 2.3*

P.7369, I 20: 'relatively low leaching fractions' – how valid are these fractions? It is very critical to point out risk areas based on this single value!

*Reply: Leaching fractions by no means are single values but region specific and based on much more detailed spatial data sets and function of a list of characteristics as explained on P7361, I1-8*

P. 7370, I. 25: 'nitrogen standards .... tend to be lower than the fertilizer recommendation'. 'tend' is not the correct term, the nitrogen standards are legally required to be lower the economic optimum.

*Reply: We do not agree that legal standards are required to be lower than economic optimum. Nitrogen standards have often been fixed at a value near the recommended N rate, notably in crop-soil combinations where this will not result in excessive nitrate leaching. One of the major motivations for the NiD was to prevent over-fertilization, so beyond the fertilizer recommendation, in areas with a surplus of manure. Legal (FE) application standards are lower than the economic optimum for all crop-soil combinations in Denmark, and for many crops on sandy soils in The Netherlands. This information is now included in the text.*

p. 7371, l. 5-8: I do not understand this sentence – is it dealing with methods for comparing recommendations, or with methods for setting recommended N in order to improve comparisons?

*Reply: Indeed unclear and this section was rewritten to: [Such differences in rotations to some extent may level out environmental effects of differences between standards for individual crops. A more elaborate analysis is needed to assess whether differences in recommendations between countries are justified in economic terms, and whether differences in application standards are justified from the environmental viewpoint. This is beyond the scope of our contribution.]*

p. 7373, l. 22: 'Recent national census data indicate that since 2008: : :.' This statement is too general – where is this published, is it valid for all countries, etc.?

*Reply: This indeed was not clear. We have replaced Figure 9 by a new graph showing indexed nitrogen fertilizer use in the three countries since 1990 in relation to the trends of prices of nitrogen fertilizer and of wheat in the EU. In the caption we provide the requested URL's to National census data. We have rewritten the paragraph to bring it into accordance with the new graph. At the end of the paragraph we have added a sentence about trends in phosphate fertilizer use, because for phosphate the effect of fertilizer price is more apparent than for nitrogen.*

p. 7375, l. 9-24: here the authors make recommendations for improvement of harmonization and effectiveness of the NiD. This is too general and does not fit in here. If the authors believe their data give basis for making recommendation the focus of the paper should be altered substantially.

*Reply: We do not agree. In our view these findings are quite specific and potentially useful for the policy community involved in the NiD. We agree that parts of the recommendations are based on other publications, but that is a normal practice in assessments. This section is now somewhat rewritten also on instigation of reviewer #2.*

p. 7375, l. 29: 'non-point agricultural sources contribute 65 % to the N load to fresh water' – where does the remaining part come from? In Denmark 90% of the total load is from non-point agricultural sources.

*Reply: We have replaced non point by diffuse. The remaining part of the load obviously comes from communal, industrial and natural sources, and a very minor part from point agricultural sources. We have added this information. Further, we decided to now use data from another source, Bouraoui et al., 2001, and given shares for the total N load to surface water. We thank the referee for the Danish value, but without a reference we cannot use it. In the data we present now the share for Denmark is 85% so quite close to the value by the referee. The new formulation is [In 2005 diffuse agricultural sources in the EU on average contributed 55% to the N load to surface waters, the remainder coming from communal, industrial and natural sources. The agricultural shares for Northwest European countries tend to be higher, ranging from 50 to 60 % in the UK, Germany, France and Belgium to 70-85% in The Netherlands, Denmark and Ireland (inferred from Bouraoui et al., 2011)]*

p. 7377, l. 1. 12: Why is 'harmonization of fertilizer recommendation systems needed' ? Please clarify.'

*Reply: We now write: [Harmonization of the rationale of national fertilizer recommendation systems is important for deriving N application standards that can lead to balanced fertilization, as required by the NiD, and eventually to create a transparent policy debate about balancing economic and environmental goals across the EU.]*

p. 7377, l. 23-26: ': : :., the NiD may need to be improved' – for what purpose? Please, clarify.

*We now write: [At some point in the future, when the first and relatively easy environmental improvements by the present implementations of NiD are achieved, the NiD may need adjustment to become more effective, notably through more specific*

*regulation of nitrogen in manure and through differentiation of targets with respect to water quality.]*

## Anonymous Referee #2

Received and published: 3 October 2012

In general we have copied adjusted text in our response. Furthermore we have marked adjustments following from review #2 in the manuscript in BLUE. Adjustments following from review #1 are marked in blue. Other adjustments are marked in yellow.

### General comments:

Van Grinsven et al. provide a detailed overview of the implementation of the Nitrates Directive (NiD) in Northwestern Europe. The study is restricted to seven countries which are among the most productive in the EU in terms of agricultural production. It compiles large amounts of information and data attained from fragmented sources such as national reports from different stages of the NiD implementation. It compares very thoroughly the differences in agricultural structures, practices and national laws within the exemplary countries. In addition to the compilation of existing data, new results from a model application are presented and compared to balances published previously. Thus, this paper provides valuable data and new findings regarding one of the most important environmental issues of European legislation. It is well written and structured and of high interest for the scientific community. I recommend this article for being published after some minor changes that are suggested in the following section:

*Reply: we thank the referee for this positive review and the thorough inspection of the manuscript*

### Specific comments:

The authors compare the results from one model (MITERRA) to balances calculated on national basis or by EUROSTAT. Results of this comparison are given for whole countries (table 12). However, MITERRA was adapted on a regional basis (Fig. 7). This gives the opportunity to check whether the model results are reasonable and reliable. A short discussion of this aspect could support the conclusions drawn from the model application.

*Reply: We have added a short paragraph on validity of MITERRA at the end of section 2.3*

One important point which is presented in chapter 3.4 are artefacts resulting from, e.g. different monitoring procedures or monitoring depths in different countries, which hinder a harmonized evaluation of the effectiveness of the NiD. This point could be stressed more strongly in the discussion or conclusion sections as one of the next required steps to improve the implementation of the NiD.

*Reply: We have added a sentence to section 4.3: [A first logical step is to further harmonize procedures for monitoring water quality and for assessing the nitrogen balance, while recognizing country specific monitoring needs to, for example, show the effectiveness of specific measures in an Action Program (Fraters et al., 2011).]*

Throughout the manuscript rates of application, leaching, etc. are given as kg ha<sup>-1</sup>. Either it should be clarified at the beginning that these values are annual fluxes or the data should be given in kg ha<sup>-1</sup> yr<sup>-1</sup>.

*Reply: Done, footnote included*

p. 7364, lines 5-7: Can these percentages be calculated from values given in table 8? What are the relative values related to? This should be clarified.

*Reply: Indeed unclear: Changed to: [While standards for forage maize and winter wheat on sandy soils are quite comparable, differences between standards for other crops and clay soils are higher, amounting to 110 kgN/ha for ware potato on clay between the Netherlands and Denmark (Table 8)]*

p. 7368, line 23: It is not clear what is the point in Figure 4. It is not much different to Figure 3. The main difference is that The Netherlands have changed to the top.

*Reply: Figure 3 plots exceedance for all groundwater samples (deep, shallow, phreatic, captive etc.) as published by the EU commission, Figure 4 plots exceedance in just shallow phreatic groundwater samples, where data are taken from detailed national reports. This is clearly stated in the captions of both figures and explained in the text on P7368, 120-24*

p. 7368, line 28 – p. 7369, line 2: There is not much use in comparing slopes of the trends (maybe with exception of The Netherlands and Denmark) since the time series have different lengths and most are more or less equal to zero.

*Reply We would challenge this statement of the referee. A key aspect of reporting on the NiD to the European Commission is about detecting trends of improved water groundwater quality as proof for effectiveness of the Action Plans. The absence of a downward trend is also relevant information as it shows that water quality is not getting worse. We only give the trends, but do not really compare the trends for reasons given on P7369 12-5.*

### **Technical corrections:**

p. 7359, line 14: Delete "in" in ": : N-losses in during housing: : ." [Done]

p. 7360, line 21: Please specify what "N losses" includes. [Gaseous is added].

p. 7361, lines 1-3: How is the leaching fraction determined? Is that part of the MITERRA model?

*Reply: yes, this is explained on P761 11-8*

Table 2: - What is meant with "runoff fraction"? Is that surface runoff? Should be specified.

*Reply: Correct and adjusted*

- Header of third column: "waters" behind "small surface" is missing - Generally, the headers of the columns no. 2 – 5 are not clear. I guess what is meant is "Fraction leaching to GW + small surface waters", "Fraction leaching to large surface waters", "Fraction of surface runoff"

*Reply: We adjusted the table according to these suggestions*

p. 7361, line 24: Define "LSU" (not mentioned before). [Done]

p. 7362, line 8: Insert slash between "and / or". [Done]

p. 7362, line 18: Define "UAA". [Done]

p. 7363, line 14: Delete "for" in ": : including for some—" [Done: sentence changed to ... *The Flemish Region has a derogation at field level and includes some arable crops*]

p. 7364, line: Change ": : based in total N: : ." to ": : based on total N: : ." [Done]

p. 7365, line 16: Define "NVZ". [Done]

p. 7366, line 26: Delete full stop after "level". [Done]

p. 7369, lines 7-8: Delete "concentrations". [Done]

p. 7369, line 11: Correct word order in ": : to tend be: : ." [Done]

Table 3: Different formulations in caption ("ruminant meat + 0.1 x total milk") and table ("0.1 x meat + milk"); What does that sum of meat and milk production mean? Please provide an explanation.

*Reply: This is explained in the caption of Table 3: ("ruminant meat + 0.1 x total milk" is a proxy for ruminant productivity. The factor 0.1 reflects the difference in energy content of 1 kg of ruminant meat relative to milk. In the shortened column heading we made an error: it should read "meat + 0.1xmilk".*

Table 5: EU-15: Presumably EU-12 is meant



*Reply: No, this is correct. In accordance with the Eurostat definition we added a footnote: \*EU15: member states between 1 January 1995 - 30 April 2004*

Table 6: - Foot note 1: Word missing in "soil mineral N autumn"? - Foot note no. 5 appears after no.8 in table

*Reply: We have adjusted the numbering of the foot notes to the order of appearance in the Table 6.*

Figure 7: Are these nitrate concentrations in groundwater or leaching water? This should be specified.

*Reply: Agree, caption changed to: [Mean nitrate concentration in leaching water in 2008 at NUTS2 level by the MITERRA model].*

p. 7377, line 25: Sentence starting with "Perhaps" is not a full sentence. Maybe it can be linked to the sentence before.

*Reply: Done: sentence now reads: [At some point in the future, when the first and relatively easy environmental improvements by the present implementations of NiD are achieved, the NiD may need to be adjusted to improve its effectiveness, notably through more specific regulation of nitrogen in manure and differentiation of water quality limits.]*