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Agri-environmental Indicators: recommendations for priority data collection and data combination

This document is the result of the DireDate project's tasks 4 and 5. DireDate stands for 'Direct and indirect data needs linked to the farms for agri-environmental indicators'. The DireDate project is a study financed by Eurostat, European Commission, and undertaken by a consortium led by ALTERRA (NL) (Service Contract 40701.2009.001-2009.354).

The general objective of DireDate is “to create a framework for setting up a sustainable system for collecting a set of data from farmers and other sources that will serve primarily European and national statisticians for creating the agreed 28 agri-environmental indicators (AEIs) and thus serve policy makers, but as well agricultural and environmental researchers, observers of climate change and other environmental issues linked to agriculture”.

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Extended summary

Introduction

Member States of the European Union (EU) are required to report regularly to the European Commission on the effectiveness of the agricultural and environmental policies. Agri-environmental indicators (AEIs) increasingly play a role in assessing the effectiveness of agri-environmental policy measures. At present much data and information is collected by Member States as input for the agreed 28 AEIs. Each AEI consists of data and coefficient that together provide the AEI. The AEIs are supposed to reflect the state or trend of a certain agri-environmental variable.

The general objective of the service contract 'DireDate' is "*to create a framework for setting up a sustainable system for collecting a set of data from farmers and other sources that will serve primarily European and national statisticians for creating the agreed 28 agri-environmental indicators and thus serve policy makers, but as well agricultural and environmental researchers, observers of climate change and other environmental issues linked to agriculture*". DireDate is carried out by a consortium of five research institutions from five Member States and has nine different Tasks.

Aims of DireDate Tasks 4 & 5

This reports presents the results of Tasks 4 and 5 of DireDate. The aims of Task 4 "Recommendations for priority data collection" are

- To summarise the AEI data needs identified in Tasks 1-3 of DireDate;
- To determine the simplest common data collection approaches applicable across multiple AEI requirements;
- To identify potential harmonisation synergies, and
- To provide recommendations for priority data collection.

The aims of Task 5 "Analysis of feasibility for data combination" are

- To analyse needs for and feasibility of AEI data complementarity and combination for the calculation of the indicators: at parcel, farm, regional or national level and the subsequent demands on the collection and processing systems

Building block approach

A number of guiding principles for developing a system for data collection and reporting were set-up, including building block principle, multiple solutions principle, primary source principle, and first things-first principle. The European Commission has indicated a set of 1st and 2nd indicators. The focus in Tasks 4 and 5 is on a first set of indicators, i.e. AEI 5 *Mineral fertiliser consumption*, 6 *Consumption of pesticides*, 7 *Irrigation*, 8 *Energy use*, 11.1 *Soil cover*, 11.2 *Tillage practices*, 11.3 *Manure storage*, 12 *Intensification/extensification*, 15 *Gross nitrogen balance*, 16 *Risk of pollution by phosphorus*, 18 *Ammonia emissions*, 19 *Greenhouse gas emissions, and* 26 *Soil quality* .

In order to assess the links in data and coefficients between AEIs, the data need of the AEIs has been unravelled and "building blocks" have been identified. Two types building blocks can be distinguished, namely those for (i) primary activity data and (ii) those for coefficients. Coefficients are here defined as "factors which can are not be derived directly from statistical surveys, and therefore have to be derived/assessed indirectly" (e.g. from scientific reports and papers or from simulation modelling). Examples of coefficients are excretion factors, emission factors, and nitrogen contents of crops.

The building blocks for the required data and coefficients for the 1st set of AEIs can be grouped in the following categories: Inputs (nutrients, pesticides, water, energy), Land cover, Crop production, Livestock production, Management (Livestock and Farm) and Soil and water quality.

Potential for harmonised data collection

Analyses of the building blocks for the the AEIs shows that there are clear differences in data needs between the AEIs. Some of the indicators are directly based on one or a limited number of activity data and coefficients (e.g. the use of nitrogen (N) and phosphorus (P) fertilizer). However, other AEIs have to be calculated from a (large) sets of activity data and coefficients (e.g. N balance, ammonia emission and greenhouse gas emissions). It is also shown that there is an overlap in the need for data in some the AEIs, and especially the AEIs related to fertilizer and manure use (N balance, ammonia emission, and greenhouse gas emissions). Moreover, all of these AEIs also include the AEIs)or data needed for these AEIs) *nitrogen fertilizer consumption*, *livestock pattern*, *cropping pattern* and *manure storage* and are related to the *Risk of phosphorus pollution*. The AEIs *irrigation*, *soil cover*, *tillage practice*, *soil erosion*, and *soil quality* are also related to yields, nitrogen balances, and risk of nitrogen and phosphorus emissions. This points at clear potential for common and harmonized data collection for part of the AEIs.

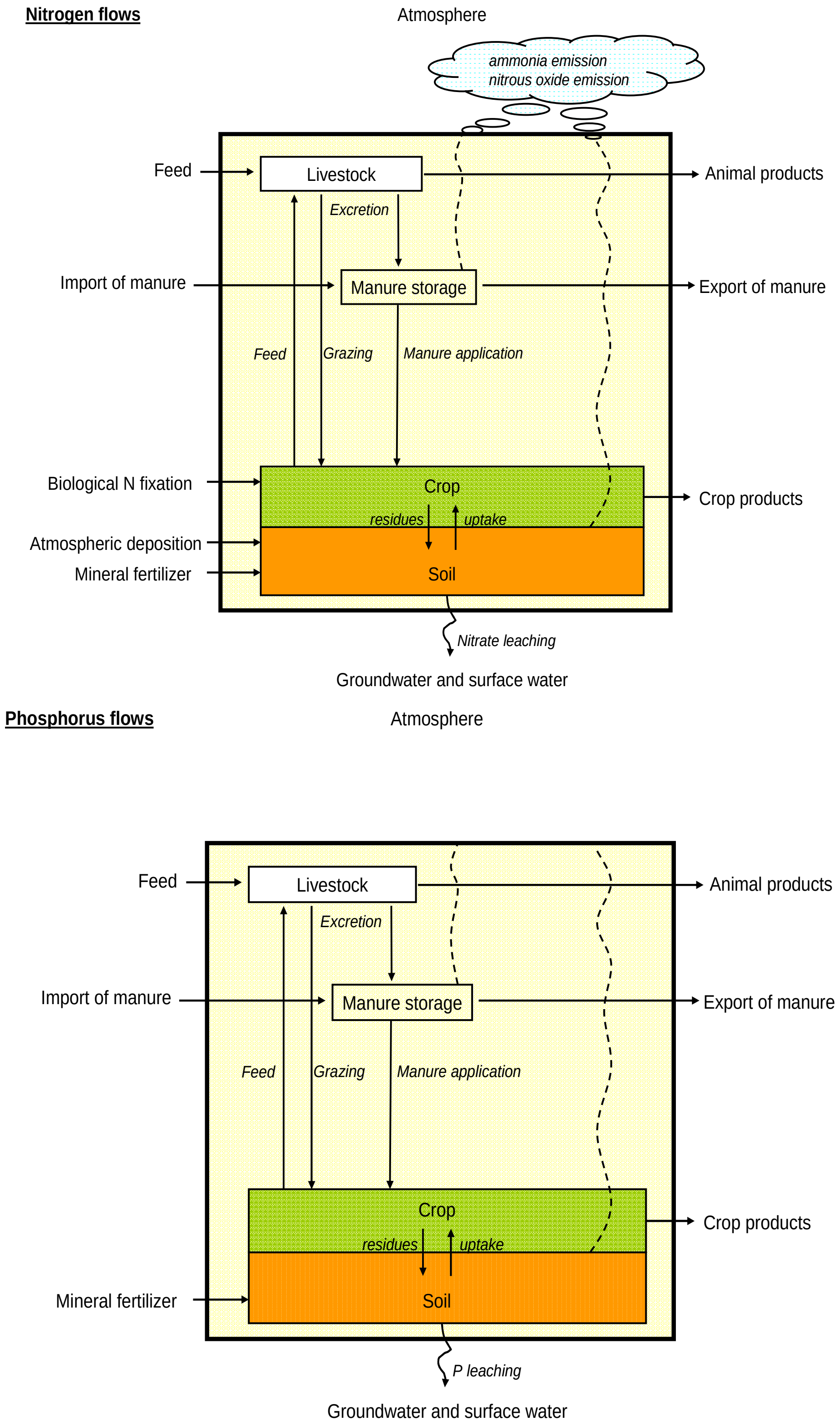
A schemes for a harmonized data collection has been developed for AEIs *gross N (and P) balances, ammonia emission, emissions of the greenhouse gases nitrous oxide (N_2O) and methane (CH_4), N and P fertilizer consumption, manure storage, soil cover, risk of pollution by phosphorus, irrigation, tillage practice, soil quality, soil erosion, livestock pattern, cropping pattern, and nitrate pollution.*

Data collection for AEIs related to manure and fertilizer use

The N and P flows in farming systems are schematically presented in Figure A. The outer box can be considered as a farm, but also as a region or country. Within the farm or region, various components are distinguished (soil, crop, livestock, manure storages). Arrows indicate the input into and output of N (upper figure) and P (lower figure) out of the farming system (delineated by the outer box). In addition, there are various internal flows.

Figure A: Schematic overview of N (upper figure) and P (lower figure) flows in farming systems

The box in each figure can be considered as farm, region or country. Notice that the total N_2 losses by denitrification are not indicated in the Figure, as these losses are not included in one the AEIs.



In Figure B the AEIs related to and depending on N and P flows and emissions of ammonia and greenhouse gases are positioned in the scheme with N and P flows. The AEIs are divided in AEIs that can be derived estimated directly on the basis of data collected in surveys and from statistics and AEI that have to be calculated on the basis of data and coefficients. The AEIs that can be derived directly from data collected in surveys and from statistics are

- AEI 5 *Mineral fertilizer consumption*. This indicator is also needed to calculate N and P balances, ammonia emission, and greenhouse gas emissions.
- AEI 11.3 *Manure storage*. This indicator is also needed to calculate ammonia and greenhouse gas emissions.
- AEI 11.1 *Soil cover*. This indicator is also needed to calculate the N and P removal by harvested crops in the N and P balance and can be used for assessment of risk of pollution by phosphorus and erosion.
- AEI 10.1 *Cropping pattern*. This indicator is also needed to calculate the N and P removal by harvested crops in the N and P balance and can be used for assessment of risk of pollution by phosphorus and erosion.
- AEI 7 *Irrigation*. This indicator can also be used for estimate of the crop yield and for assessment of risk of pollution by phosphorus and erosion.
- AEI 11.2 *Tillage practice*. This indicator can also be used for assessment of risk of pollution by phosphorus and erosion, and for the soil quality indicator.
- AEI 10.2 *Livestock pattern*. This indicator is also needed to calculate the N and P excretion by livestock.
- AEI 27.1 *Nitrate pollution* (measured water quality).

The AEIs that have to be calculated using data (which may include other AEIs) and coefficients are

- AEI 15 Gross *N balance*;
- AEI 18 Ammonia emission;
- AEI 19 Greenhouse gas emissions (N_2O and CH_4);
- AEI 16 *Risk of* pollution by phosphorus;
- AEI 26 Soil quality;
- AEI 21 Soil erosion.

A calculation scheme has been set up with steps for data collection and processing so as to derive all the AEIs discussed in this chapter. The aim of this calculation scheme is to set up of systematic approach to collect data and coefficients and to harmonize data collection and processing (data and coefficients) that have to be used for different AEIs. A calculation scheme with 12 steps has been set up (see Figure B).

Step I. Calculate the total annual N and P excretion by livestock during grazing and in housing. The excretion of carbon may be included if it is needed for calculating methane emissions from manure storage.

Required data:

- The number of livestock per category.
- The N, P and C excretion per animal category per year.
- The portion of the manure excreted in housing and during grazing (calculated from housing/grazing days).

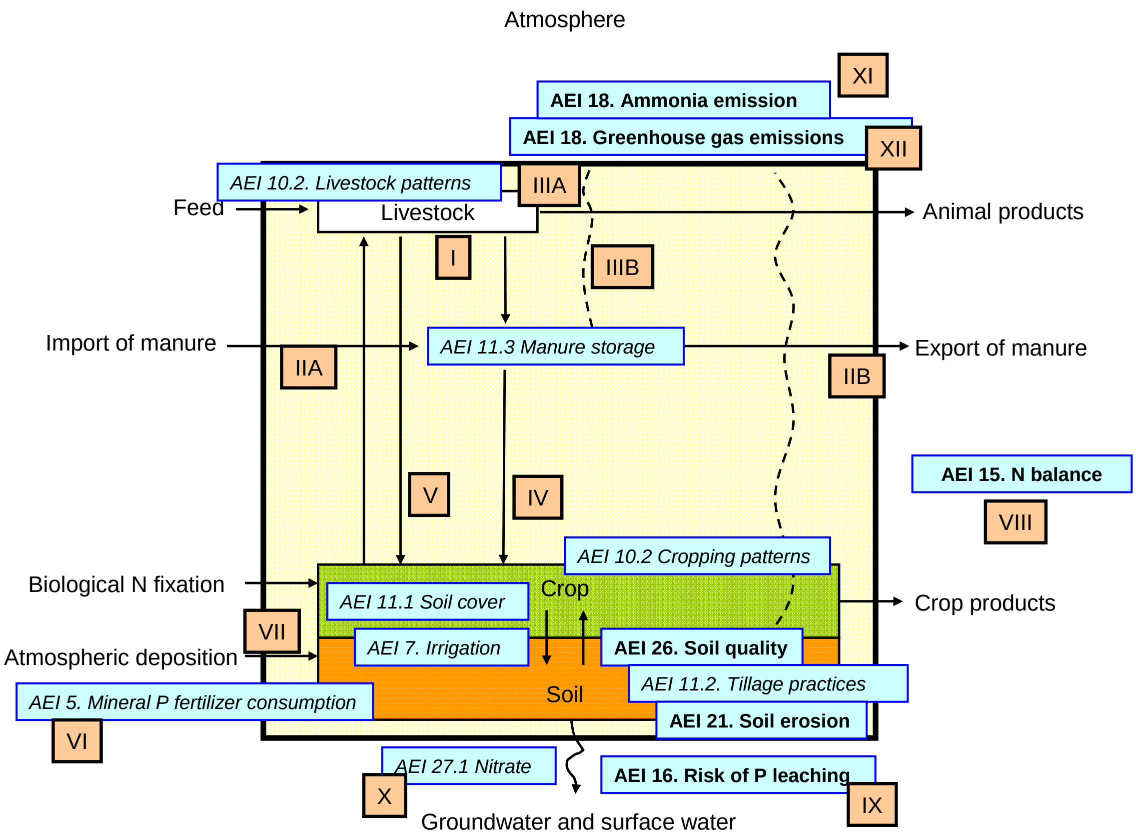
Step II. Calculate the amounts of N and P imported (IIA) and/or exported (IIB) as manure.

Required data:

- Export and import of manure per year and the contents of N and P of this manure.

Figure B: Scheme with calculations steps for data collection and processing to estimate the AEIs related to emissions of N and P balances and emissions of ammonia and greenhouse gases

The steps (Roman numbers in boxes) are explained in the text.



Step III. Calculate the gaseous emissions from livestock (IIIA), housing and manure storage (IIIB) per year: N2O, NH3, and CH4. In order to calculate the amount of N that is transported from manure storage to the field, also the N2 emission has to be calculated.

Required data:

- The minimum data requirements for calculating CH_4 emission from enteric fermentation are the type of livestock and emission factors for CH_4.
- Amount of stored manure, expressed in mass of N and C (derived from the calculations in Steps I and II) per year,
- Emission factors for NH_3, N_2O, N_2, and CH_4 dependent of type of housing,

Step IV. Calculate the amounts of manure N applied to the soil, and the associated emissions of NH3 and N2O.

Required data:

- Amount of N applied as manure per year, divided over crop and grassland areas. The amount of N applied is calculated as: the amount of excreted N in housing - the export of manure N and P + the import of manure N – gaseous N emissions from housing and storage (NH_3 + N_2O + N_2).
- Emission factors for NH_3 for different application techniques, and if available for soils and crops.

Step V. Calculate the amounts of N and P excreted during grazing, and the associated emissions of NH3 and N2O.

Required data:

- N and P excretion (result of calculation in Step II) during grazing per year,
- Grassland area, and
- Emission factors for NH_3 and N_2O.

Step VI. Calculate the amounts of N and P applied as N and P fertilizer, and the emissions of NH3 and N2O associated with N fertilizer use.

The application of nitrogen and phosphorus via mineral fertilizers are needed. The emissions are dependent of the type of N fertilizer. Data of soil cover (area grassland, fodder crops and arable crops) are needed to calculate the application rates per ha.

Required data:

- Amounts of N and P fertilizer use per year,
- Crop and grassland areas (soil cover), and
- Emission factors for NH_3 and N_2O for different types of N fertilizers.

Step VII. Calculate the N inputs via biological N fixation and atmospheric N deposition and related N2O emissions

Required data:

- Biological N fixation
- Atmospheric N deposition

Step VIII. Calculate the Gross N balance

Required data:

- N inputs
  - Manure N applied (**Step IV**). For the soil N balance, the gaseous N losses during housing and from manure stored has to be extracted from the N excretion, so as to estimate the actual amount of N applied.
  - N excreted during grazing (**Step V**).
  - Mineral N fertilizer application (**Step VI**).
  - Biological N fixation (**Step VII).**
  - Atmospheric N deposition (**Step VII).**
- N outputs:
  - N removed by harvested crop products (yields), calculated from the yields and N contents of the harvested products per year, cropping patterns (including catch crops and winter crops; soil cover) and grassland area. The AEI 7 *Irrigation* can be used to estimate the yield.

Step IX. Calculate the risk of pollution by phosphorus.

The risk of pollution by phosphorus is calculated as the P surplus on the P balance, i.e. the difference from the P inputs via i) mineral fertilizer, ii) manure, and iii) grazing and the P output via crop removal, including the P removed by cut or grazed grass. This is the main indicator. The vulnerability to phosphorus leaching and run-off is a supporting indicator. A method to quantify the vulnerability to phosphorus leaching and run-off needs further development, and may include, in addition to the P balance, AEIs 11.1 *Soil cover*, AEI 26 *Soil quality* (including soil P status), AEI 7 *Irrigation*, AEI 11.2 *Tillage practice*, AEI 21 *Soil erosion*, and climate, topography, hydrology.

Required data:

- P inputs
  - Manure P applied (**Step IV**).
  - P excreted during grazing (**Step V).**
  - Mineral P fertilizer application (**Step VI**).
- P outputs:
  - P removed by harvested crop products (yields), calculated from the yields and P contents of the harvested products per year, cropping patterns (including catch crops and winter crops; soil cover) and grassland area. The AEI 7 *Irrigation* can be used to estimate the yield.

Step X. Nitrate pollution

Data of measured nitrate concentrations in groundwater and surface waters have to be collected at well-defined and described sampling stations, through monitoring programs. For groundwater, one or two samples per years is usually sufficient, for surface waters monthly or quarterly samples have to be taken and analyzed.

Step XI. Ammonia emissions

The AEI 18 *Ammonia emissions* is calculated as the sum of the emissions from housing and manure storage (**Step III**), manure application (**Step IV**), grazing (**Step V**), and mineral N fertilizer (**Step VI**).

Step XII. Greenhouse gas emissions

The AEI 19 *Greenhouse gas emissions* is the sum of nitrous oxide, methane and carbon dioxide emissions, all expressed in carbon dioxide equivalents per ha per year. In this report, the non-CO_2 greenhouse gas (N_2O and CH_4) emissions are considered only, as agriculture is the main source of these greenhouse gases.

The total direct nitrous oxide emission is calculated as the sum of the emissions from housing and manure storage (**Step III**), manure application (**Step IV**), grazing (**Step V**), and mineral N fertilizer application (**Step VI**).

The total methane emission is calculated as the sum of the methane emission from livestock (enteric fermentation; **Step II**) and storage of manure (**Step III**).

The total indirect nitrous oxide emission (i.e. the emission related to ammonia emissions and nitrate leaching) have to calculated as:

- Total ammonia emission (**Step XI**) and the emission factor for the indirect nitrous oxide emission from ammonia.
- Total N input to the soil (see **Step VIII**), the leaching fraction (for example, the $FRAC_{leach}$ factor of IPCC), and the emission factor for the indirect nitrous oxide emission from nitrate leached.

Required data:

- The emission factor for the indirect nitrous oxide emission from ammonia,
- The emission factor for the indirect nitrous oxide emission from nitrate,
- The nitrate leaching fraction.

Data collection for the other Agri-Environmental Indicators

The AEIs in Figure F are related to fertilizer and manure use, emissions of ammonia and greenhouse gases to the atmosphere, and the loss of nitrate and phosphorus to groundwater and surface waters via leaching and run off. Most of these AEIs have a common basis as regards required data and as a result a solid basis for harmonized methods and procedures of data collection and processing.

There are a number of AEIs (from both the first and second set) not covered by this scheme.

There are three AEIs, which are linked with the AEIs in Figure B, i.e.

- AEI 13. *Specialisation*, related to many AEIs, including fertilizer consumption, cropping patterns, livestock patters, Soil cover, Tillage practice, N balance, and risk of P pollution.
- AEI 12. *Intensification/extensification*, related to fertilizer use, livestock and crop patters, and

irrigation.

- AEI 20. *Water abstraction*, related to irrigation

The following data have to be collected at least for AEI 12 *Intensification*:

- Input of mineral fertilizers, energy and pesticides;
- Livestock density and amounts of purchased feed;
- Ratio between input and output in monetary terms.

From the remaining AEIs, three AEIs are related to use of pesticides:

- AEI 6 Pesticide consumption
- AEI 17 Pesticide risk
- AEI 27.3 Pesticide in water

There are two AEIs related to energy, i.e.

- AEI 24 Production of renewable energy
- AEI 8 Energy use

Finally, there is a group of AEIs related to land use and the ecological impacts of farming systems, from which part have linkages with each other.

- AEI 1 Agri commitments
- AEI 3 Farmers training
- AEI 4 Area under organic farming
- AEI 2 Agricultural areas under Natura 2000
- AEI 9 Land use changes
- AEI 14 Risk of Farmland abandonment
- AEI 22 Genetic diversity
- AEI 23 High nature farmland
- AEI 28 Landscape
- AEI 25 Farmland birds

It is recommended to use the following approach and procedures for data:

1. Collect the data for the AEIs related to manure and fertilizer use, as indicated in Figure F.

2. Collect the data for AEIs which are closely related to those of Figure F.

3. Collect data related to pesticides.

4. Collect data related to energy.

5. Collect data related to land use and ecological impacts of farming.

Approaches and procedures to collect data

In the DireDate project a prime focus was on AEIs related to nitrogen and phosphorus balances and greenhouse and ammonia emissions, as several EU policies demand these data. The AEIs related to manure and fertilizer have the most in common with policy data requirements and that they have coefficients represented across multiple policies include the following. Highest priority should be given to the collection of those data that have largest effects on the N and P balances and ammonia and greenhouse emissions. The following type of data can be distinguished:

- Data related to inputs of N and P to agricultural systems, as they affect both N and P balances and ammonia and greenhouse gas emissions.
- Data and coefficients related the emissions of ammonia and greenhouse gases, i.e. factors that determine the emissions that occur from manure and N fertilizers, such the type of housing, manure storage, and application technique.
- Data and coefficients related to the output of N and P in the gross N and P balance, i.e. the N and P in harvested crop products.

This paragraph summarizes the recommendations related to the N and P input data collection and processing. It also briefly summarizes the possible consequences of these recommendations.

N and P input data collection and processing

- Each Member State should establish a working group of experts related to the derivation of N and P excretion rates, for all livestock categories. This working group should establish the methodology, and once approved should use this methodology for estimating the N and P excretion rates each year, for all livestock categories. The methodology as well as the annual N and P excretion rates, for all livestock categories, should be made available to others and should be used for all policy reports (e.g. Nitrates Directive, National Emission Ceilings Directive, UNFCCC, UNECE-CLRTAP, Rural Development Program, Sustainability Indicator, N and P balances for OECD, FAO, etc.).
- There are no recommendation about changing the number of livestock in FSS. It recommended that Eurostat takes the lead in exploring the possibility (and reliability) to use the livestock registers for the number of cattle, pigs, sheep, goat, and horses. This should be carried in close corporation with the member states.
- Eurostat has to explore if SAPM can be used for estimating the grazing days. If not, recommendations should be made how to collect grazing days in FSS.
- The collection and processing of N and P fertilizer use, demands for several actions:
  - Improve the statistics of national fertilizer consumption. This has to be done by the member states, together with Eurostat, in consultation with Fertilizers Europe (EFMA) and (national) fertilizer trading associations. The first step is that the member states indicate the uncertainties and difficulties in obtaining data on fertilizer use in their country. Part of possible problems will be country-specific, but part of the problems will be the same for several member states. It is recommended that Eurostat and FAO make a synthesis of the problems related to collecting data of fertilizer consumption, and discuss this with Fertilizers Europe (EFMA). EFMA already has a fertilizer statistics in place, which can help to improve the quality of the estimates of different member states (http://www.fertilizerseurope.com).
  - Each Member State should establish a working group of experts to derive a methodology to disaggregate national fertilizer consumption data to crop-specific data at regional scale (NUTS-2). This is a temporal activity, and can be done in a project. However, management

and improvement of the methodology is a permanent activity and must be carried out preferably by the working group of experts or by a research institution.

- Set up of targeted surveys to validate and improve the methodology of deriving crop-specific and regional-specific N and P fertilizer use data on the basis of the disaggregation of national fertilizer consumption statistics. The set-up of these surveys is dependent on the results of the developed disaggregation procedure. It is recommended that National statistical offices will carry out these surveys and process the data, as they have most experiences in surveys. However, the validation of the methodology and improvement of the estimates should be carried out by scientists (working group) involved in the development of the methodology.
- The application of the methodology for deriving crop-specific and regional-specific N and P fertilizer use data should be done by the national statistical offices.
- The methodology as well as the annual crop-specific and regional-specific N and P fertilizer use data should be made available to others and should be used for all policy reports (e.g. Nitrates Directive, National Emission Ceilings Directive, UNFCCC, UNECE-CLRTAP, Rural Development Program, Sustainability Indicator, N and P balances for OECD, FAO, etc.).
- Each Member State should establish a working group of experts (agronomists) to establish a methodology for the derivation of N fixation by clover in grasslands. It is also recommended to organize a workshop at EU-27 level with all scientists and agronomists involved, in order to discuss and approve the methodologies and to derive the best estimates of N fixed by clover on regional level in EU-27.
- Data of dry and wet N deposition are available at EMEP-website at different spatial and temporal scales. It is recommended that Eurostat consults EMEP about use of N deposition data in the calculation of the N balances.

Collection of data and coefficients related the emissions of ammonia and greenhouse gases

For type of housing and manure storage systems, it is recommended to collect data on a farm level (farm survey) every 5 years. On the short term (< 2 years) information of the type of manure should be collected, i.e. systems based on solid and liquid manure, as type of manure has a large effect of ammonia, nitrous oxide, and methane emissions. On the intermediate term (2-5 years) it is recommended to collect systems according the IPCC guidelines. For the long-term (> 5 years) it is recommended to collect data to be used in Tier 2 or 3 approaches to calculate emissions. It is recommended to include (and expand) the collection of types of housing and manure storage in the Survey on Agricultural Production Methods (SAPM) of FSS.

For collecting data of manure application techniques, it is recommended to collect on short-term (< 2 years) data on application techniques not aiming at reducing ammonia emission (i.e. broadcast or no incorporation) and reduced ammonia application techniques (i.e. the other techniques). At the short term, estimates derived for the GAINS model can be used (i.e. partly based on consultation of member states) and start a survey to collect data on farms. For the long-term (> 5 years) it is recommended to collect the data of more types of application techniques. It is recommended to include (and expand) the collection of types of housing and manure storage in SAPM.

There are already good guidebooks, working groups and/or task forces in place to derive methods and coefficients to estimate ammonia and greenhouse gas emissions, i.e. the IPPC (IPPC guidelines), different taskforce under the UNECE, and the EMEP/EEA Guidebook. There is no further action needed to improve the methodologies and coefficients and EU member states are recommended to use Tier 2 or 3 approaches to estimate ammonia and greenhouse gases.

Collection of data and coefficients related to the output of N and P in the gross N and P balance

For calculation of the outputs data on the yields and N and P contents of the crop products are needed. For the yields, the current data collection system of Eurostat and member states can be used. However, it is recommended to evaluate the procedures followed by the different countries (estimates by local experts or measured) and to verify if the estimated yields are the average yields. The yields of major crops in a member states should be collected at the regional level, especially in large countries with regional differences in climatic conditions (and other factors affecting yields, such as soil type).

A methodology should be developed to estimate the grassland yields in different countries/regions in EU-27, taking the different management types into consideration (rough grazing, extensively managed, and intensively managed). This estimated may be based on empirical data (field experiments), results of crops models, expert estimates, and feed balances of dairy cattle (i.e. the feed N take can be estimated from the milk yield). It is recommended to install a working group (or start a project) with scientists, agronomists, and statisticians of different member states in order to develop such a method.

The yields obtained in the surveys and in the It recommended to verify if the estimates and forecasts made by the Monitoring Agricultural Resources (MARS) Unit of JRC can be used as a source of yields or validation of yields.

It is recommended to carry out a desk study to obtain the N and P contents in the crop products in different regions in EU and/or in dependency of the N and P inputs, as it is known the N and P contents are dependents of the N and P inputs, respectively.

1 Introduction

1.1 Background and aims

Agriculture exerts various effects on the environment. These effects depend on both the agricultural activities and the environmental conditions. Agriculture in the European Union (EU) is highly diverse and also dynamic, as agriculture responds to changes in markets, technological developments and governmental policy. As a consequence, effects of agriculture on the environment are spatially diverse and change over time.

The Common Agricultural Policy (CAP) and Rural Development and Environmental Regulations and Directives of the EU have a strong influence on agriculture and its effects on the environment. The general objectives of these policies are to making EU agriculture more productive, competitive and environmental sound, whilst safeguarding the livelihoods and natural values of rural areas. Member States of the EU are required to report regularly to the European Commission on the effectiveness of the aforementioned policies. Agri-environmental indicators (AEIs) increasingly play a role in assessing the effectiveness of agri-environmental policy measures.

At present much data and information is collected by Member States as input for the agreed 28 AEIs. Each AEI consists of one or more coefficients/data that together provide the AEI. The AEIs are supposed to reflect the state or trend of a certain agri-environmental variable. However, at present agricultural statistics mainly focus on economic and production issues and less on agri-environmental issues. Consequently, agricultural statistics are used, or modified towards, the objectives of the AEIs. The usefulness of this practice depends on the geo-reference of the data (‘Does the data reflect spatially explicit activities/trends?’), geo-physical setting of the farm (‘Does the data reflect differences in farm strategies?’) and continuity of data collection (‘Is the data collected in a consistent and systematic monitoring protocol?’).

The general objective of the service contract ‘DireDate’ is “*to create a framework for setting up a sustainable system for collecting a set of data from farmers and other sources that will serve primarily European and national statisticians for creating the agreed 28 agri-environmental indicators and thus serve policy makers, but as well agricultural and environmental researchers, observers of climate change and other environmental issues linked to agriculture*”. DireDate is carried out by a consortium of 5 research institutions from 5 Member States and has 9 different Tasks.

This reports presents the results of Tasks 4 and 5 of DireDate. The aims of Task 4 “*Recommendations for priority data collection”* are

To summarise the AE data needs identified in Tasks 1-3;

- To determine the simplest common data collection approaches applicable across multiple AEI requirements;
- To identify potential harmonisation synergies, and
- To provide recommendations for priority data collection.

The aims of Task 5 “Analysis of feasibility for data combination" are

- To analyse needs for and feasibility of AE data complementarity and combination for the calculation of the indicators: at parcel, farm, regional or national level and the subsequent demands on the collection and processing systems

The output for Task 4 consists of a review of the data needs, identifying potential harmonisation synergies and giving recommendations for priority data collection.

The output for Task 5 consists of a list of recommendations for data combination or opportunities for multiple application and use beyond those for which the data were originally collected.

The analyses for both Tasks have been carried out together and in this report the results of both Tasks are not reported separately.

In Chapter 2 of this report, the used methods are described, including the guiding principles which have been followed in the assessment. The results of Tasks 1-3 of DireDate are summarized in Chapter 3. The common needs for data for the first set AEIs are identified using the building-block principle in Chapter 4. Also the common data need for data in policies are addressed in the Chapter. In Chapter 5, a scheme for common data collection for AEIs related to the use fertilizer and manures is presented. This Chapter also includes a description of the nitrogen (N) and phosphorus (P) flows in farming systems. Chapter 6 focuses on the priority of data collection, with emphasis on the required spatial and temporal scales and the required level of detail for the methodology to calculate AEIs. Finally, in Chapter 7 recommendations for collection of data related to inputs of manure and fertilizer are presented. Moreover, this Chapter contains recommendations about the approaches and procedures to collect the required data.

2 Methods

2.1 Guiding principles

A number of guiding principles for developing the requested "*framework for setting up a sustainable system for data collection and reporting*" have been identified. These guiding principles are used in the analyses of data needs for the different indicators and the development of new and effective approaches for data collection:

1. Building block principle, i.e., design the framework and its building blocks in a way that it provides flexibility. The building blocks should be identified based on an analysis of their usability, i.e. nr of times used for nr. of different functions. The framework has to be robust (sustainable) and flexible at the same time, to be able to adjust to future changes;
2. Multiple solutions principle, i.e., there is not just one optimal solution for deriving the framework, but a range of possible solutions. Hence provide various proposals and indicate their pros and cons and 'margins of flexibility';
3. Primary source principle, i.e., data collected directly at source, at the farm level, likely have a larger accuracy than data derived from indirect sources;
4. Effectiveness and efficiency principles, i.e., collect the data only the number of times that is necessary to provide a sensible impact assessment. Use the data many times, but transmit the data only once, and cluster data where possible;
5. First things-first principle, i.e. the emphasis of the work has to be on the most important aspects. The priority activities have to be identified and these have to be carried out. As indicated in COM 2006, there are a number of indicators which are not well-elaborated yet. It is not the work of the Consortium to develop these AEIs. Hence, the priority of the Consortium lies at the so-called first set of indicators (these are well-defined and well-described)
6. Subsidiarity principle, i.e., consider that the central authority should have a subsidiarity function, performing only those Tasks which cannot be performed effectively at a more immediate or local level; which competences should be given to the EU and which retained for the member states alone?

2.2 Approach followed in Tasks 4 and 5

The results of Tasks 1, 2, and 3 of DireDate have been summarized in tables and flow charts, and linkages between data requirements for the individual AEI's are indicated.

The following steps have been be carried out (see Figure 1):

1. Task 1 delivered fact sheets with description of the different AEIs and the required data and coefficients.
2. Priorities (first things first principle). The Commission has indicated a 1st and a 2nd set of indicators (which include the AEIs of Task 3). Moreover, the AEIs which are part of reporting in existing policies (Task 2) have a high priority, because there are obligations to report these AEIs (Table 1)

3. Linkages in data need for the different AEIs have been identified. Firstly, linkage has been identified at AEI level and, thereafter, at the detailed data and coefficient level. For all data and coefficients (the building blocks of AEIs), it has been indicated in Task 1 if it is already collected in current information systems or if it is obliged to be collected for certain policies. If the information is not yet collected, the advantages and disadvantages of collection of this information at a detailed level will be described. In Task 1 the ideal data and coefficients for each AEI have been indicated. The focus of Tasks 4 & 5 is on feasible data collection.

The potential for harmonization of collection of data are described.

Figure 1: Steps followed in Tasks 4 and 5

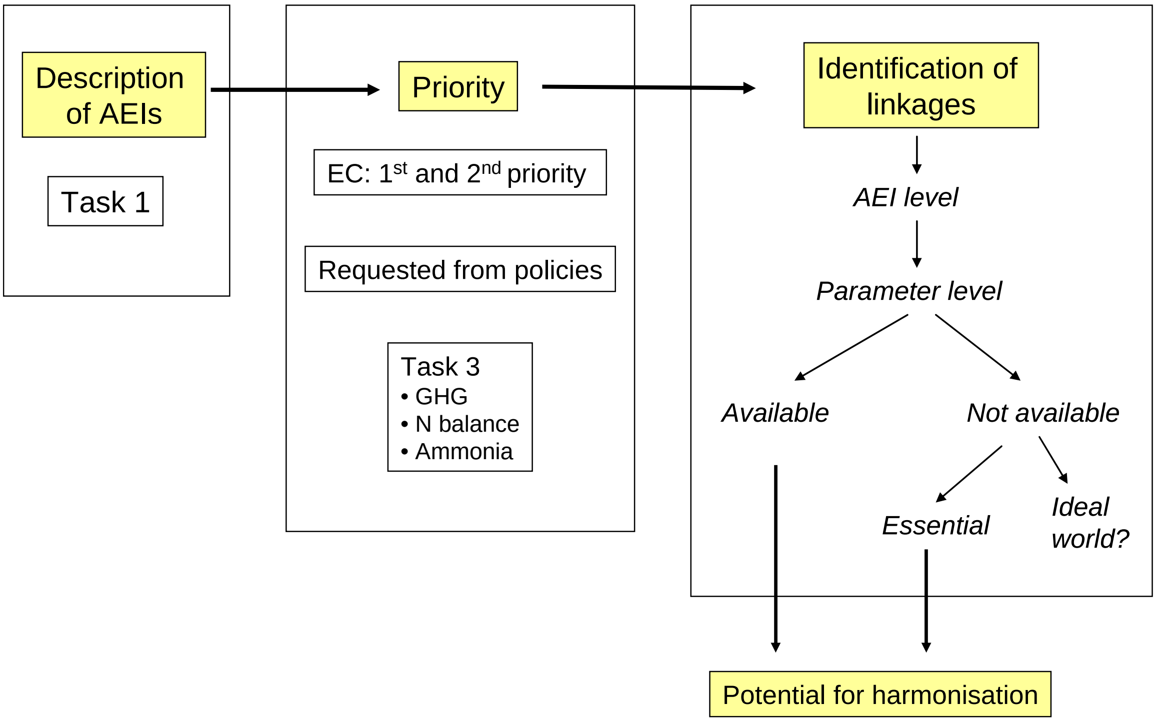


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Table 1: List of the first set and second set of agri-environmental indicators, as indicated by Eurostat in December 2009

First set of indicators	
5	Mineral fertiliser consumption
6	Consumption of pesticides
7	Irrigation
8	Energy use
11.1	Soil cover
11.2	Tillage practices
11.3	Manure storage
12	Intensification/ extensification
15	Gross nitrogen balance
16	Risk of pollution by phosphorus
18	Ammonia emissions
19	Greenhouse gas emissions
26	Soil quality

Second set of indicators	
1	Agri-environmental commitments
2	Agricultural areas under Natura 2000
3	Farmers' training levels and use of environmental advisory services
4	Area under organic farming
9	Land use change
10.1	Cropping patterns
10.2	Livestock patterns
13	Specialisation
14	Risk of farmland abandonment
17	Pesticide risk
20	Water abstraction
21	Soil erosion
22	Genetic diversity
23	High nature value farmland
24	Production of renewable energy
25	Population trends of farmland birds
27.1	Water quality – Nitrate pollution
27.2	Water quality – Pesticide pollution
28	Landscape – State and diversity

3 Summary of data needs identified in Tasks 1-3 of DireDate

In this Chapter a summary is presented (as tables) of the results of Tasks 1-3 of DireDate.

3.1 Task 1

The objective of Task 1 was to identify the data requirements and availability and the possible gaps in AEIs. The objective was to characterize the ideal situation of data collection and the distance currently from it. In the report of Task 1 fact sheets are presented for each AEI. These fact sheets include the data requirement for each AEI. In Table 2 a summary is given of the data requirement of the priority indicators (see report Task 1 for more details). The data required for ammonia emission, greenhouse gas emissions, and N balances are described in detail in Task 3 (see paragraph 4.3). It is indicated that the AEI *Soil quality* indicator does not yet have an approved definition, by which it is not yet possible to define the data. For the AEI *intensification and extensification* it is indicated that a range of data collected at farm level is required, but there is not yet a set of specified coefficients needed for this AEI.

3.2 Task 2

The objective of Task 2 was to analyse the reporting needs of EU policies that relate to AEIs and require the collection of related data. Table 3 shows the common data requirements for AEI indicators and the nine reviewed policies. The EU policies that are covered by Task 2 are (see report Task 2 for more details):

- United Nations Framework Convention on Climate Change (UNFCCC)
- Land-use, Land-use Change and Forestry (LULUCF) (UNFCCC sector)
- Rural Development Programme (RDP)
- Water Framework Directive (WFD)
- Nitrates Directive (ND)
- National Emissions Ceiling Directive (NECD)
- Framework Directive on the Sustainable Use of Pesticides (FDSUP)
- Birds & Habitat Directive (BHD)
- EU Strategy for Sustainable Development (EU SDS)

From Table 4, it can be ascertained that the majority of coefficients required for calculation of AEIs are also required, at least in part, for environmental policy. Below exceptions are presented. The AEIs marked with * in the list below do not have any coefficients that are fully aligned with policy requirements. The AEIs that are not directly required by polices are (in italic the main indicator is presented and in Roman the supporting indicators):

- 3. Use of environmental farm advisory services and farmers' training (Number of farmers having practical experience)
- 7. *Irrigation** (Area irrigated once/year)
- 11.1 *Soil Cover* (Soil coverage index values)
- 11.2 *Tillage practices* (Area managed by conservation or zero tillage)
- 12. *Intensification/ extensification** (Expenditures for inputs)
- 16. Risk of pollution by phosphorous* (Soil characteristics)
- 22. *Genetic diversity** (number of crop varieties and livestock breeds)
- 28. *Landscape* – State and diversity – (number of agricultural classes/ number of crops)

Other coefficients are not fully compatible with data requirements for policy. These are;

- 5. *Mineral fertiliser consumption* (application rates per crop of P)
- 7. *Irrigation** (Total irrigable area)
- 11.2. *Tillage practices** (Area managed by conventional tillage)
- 12. *Intensification/ extensification** (Milk yields/ Cereal yields)
- 13. Specialisation*
- 14. Risk of land abandonment*
- 15. *Gross nitrogen balance* (Atmospheric deposition/ Crop yields)
- 16. Risk of pollution by phosphorous* (phosphorous consumption)
- 28. *Landscape* – State and diversity (Agriculturally linked linear elements/ Rural tourism)

The AEIs for which data requirements have the most in common with policy data requirements and that have coefficients represented across multiple policies include the following;

- 5. Mineral fertiliser consumption
- 10.2. Livestock patterns
- 11.3. Manure storage
- 15. Gross nitrogen balance
- 17. Pesticide risk
- 19. GHG emissions
- 27.1. Water quality – Nitrate pollution

Table 2: Data requirements AEI (summary Task 1 of DireDate)

AIE	Scale and frequency	Required data								
5 **Mineral fertiliser consumption**	Ideally, at farm level each year.	Fertilised area per farm (ha)	Amount of fertilizer N applied (kg N per farm per year)	Amount of phosphorus applied (kg P per farm per year)	Amount of fertilizer N applied per crop type (kg N per crop per year)	Amount of phosphorus applied per crop type (kg P per crop per year)				
6 **Consumption of pesticides**	Ideally, at farm level each year.	Pesticide treated area per farm (ha)	Amount of pesticides applied (kg active ingredient (ai) per farm per year) divided in the categories herbicides, insecticides, and other	Number of treatments per year with herbicides, insecticides, and other	Alternatively, the following information should be available at Member State level:	Sales data for each active ingredient (can be derived from product sales data)	Use pattern for each active ingredient (could partly be derived from product sales data)	Dose rate for each active ingredient and use		
7 **Irrigation**	Ideally, at farm level each year.	Irrigated area (ha) (yearly)	Amount of water used (mm per ha) and per crop per year and per month	Source; ground or surface water	Type of irrigation installation/ infrastructure					
8 **Energy use**	Ideally, at farm level each year	Direct energy use in MJ per farm per year, specified according to fuel type (oil products, natural gas, coal, electricity, derived heat); and	Indirect energy use in MJ per farm per year related to the purchase of farm inputs: fertilizers, pesticides, machines, buildings, purchased feed, etc;	Type of farming system (glasshouse, arable farming, horticulture, dairy farming, beef farming, pig, poultry, etc	Farm area (ha)	Number of farm animals	Main crops	The coefficients for the estimation of the indirect energy use from purchased fertilizers, pesticides, machines, buildings and animal feed must be specified These coefficients may vary significantly between different literature sources as they do not have a common and certified basis		
11.1 **Soil cover**	At farm level	Total arable area (ha)	Area with winter crops (ha)	Dates of sowing and harvesting	Number of days from sowing until crop is established	Straw removed or incorporated in soil?	Area with catch crops (ha)			
11.2 **Tillage practices**	At farm level	Area managed by reduced tillage	Area managed by zero tillage (direct seeding)	Area managed by conventional tillage						

AIE	Scale and frequency	Required data								
11.3 Manure storage	Ideally, at farm level each year	Type of manure (animal type, solid/liquid or slurry)	Type of storage (solid storage combined with liquid system, slurry tank, lagoon, covered, sealed on the ground, etc)	Storage capacity (months)	Time of spreading (autumn, spring, all year around)	Spreading technique (broad spreading/hose trail spreading/direct injection)				
12 Intensification/ extensification		Ideally intensity classifications should be based on a range of data collected at farm level These data should provide a detailed picture on a range of practices determining the environmental pressures a farm exerts on the environment, but also the potentially positive contribution farms may have on biodiversity and habitats Overall it is however clear that input levels to be linked to output levels are the best indicators for expressing intensity Ideally they should be provided at the farm and even field level enabling not only the classification of farms in intensity classes, but also the farm land categories								
15 Gross nitrogen balance		Statistical data on crop and forage production and number of animals are converted to input and output of N using a number of different coefficients, such as manure N produced per head of different animal categories, N fixed per hectare by leguminous crops, and N removed with cash crops and forage See Task 3 for details								
16 Risk of pollution by phosphorus	Ideally at field or finer scales:	Crop management; cropped and fertilised area (ha)	Amount of fertilizer and manure P applied, preferably historic account of (kg P per ha per year)	Phosphorus status of soils, soil test P values (low, medium or high P content)	Surface water map including streams, ditches, lakes, etc)	Terrain attributes from high-resolution digital elevation models	Soil maps including texture and information on P sorption capacity	Landscape elements and field maps including buffer zones along water courses	Drainage maps	Detailed climate records
18 Ammonia emissions	The data requirements are described fully in Task 3									
19 Greenhouse gas emissions	The data sources are described fully in Task 3									
26 Soil quality	Soil quality does not yet have an approved definition and description and therefore it is not possible to define the data requirements									

Table 3: Summary of Task 2 – Common data requirements for AEI indicators and the nine reviewed policies

A double tick is given when the data requirement under the policy exactly Common data requirements for AEI indicators and the nine reviewed policies. A double tick is given when the data requirement under the policy exactly fulfils the parameter requirement of the indicator. A single tick is given when the data provision under the policy contributes some, but not all, of the data for the parameter. Parameters in bold are measurements for the main indicator, and others are for supporting indicators. The level of detail required by the policy is outlined in the footnotes.

INDICATOR	PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
		UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
1 **Agri-Environmental commitments**	**Share of area under AE commitments / total UAA**	×	×	✓✓[1]	×	×	×	×	×	✓✓[2]
	Area under AE commitments (per category)	×	×	✓✓[1]	×	✓[3]	×	×	×	×
	Area under AE commitments within Natura 2000 sites	×	×	✓[4]	×	×	×	×	×	×
	Share of agricultural holdings with agri-environmental commitments/ total number of agricultural holdings	×	×	✓[5]	×	×	×	×	×	×
	Share of total expenditure for AE payments/ total rural development expenditure	×	×	✓✓[6]	×	×	×	×	×	×
	AE payments/ UAA	×	×	✓✓[6]	×	×	×	×	×	×

[1] RDP - Physical area under AE commitment required at MS level by measure. Total UAA required at MS level as a baseline indicator.

[2] SDI – Area under agri-environmental commitment is calculated as % of UAA enrolled in AE measures. Excluded from 2009 report due to quality concerns.

[3] ND - Area under NVZ mandatory action programme commitments required at MS level.

[4] RDP – Supported agricultural land under N2K (Measure 213) and supported forest land in N2K (Measure 224) required at MS level where applicable.

[5] RDP – Number of holdings under AE commitment required at MS level by measure. No information on total number of holdings required.

[6] RDP – Total expenditure for AE schemes required at MS level, as is total RDP expenditure and total UAA.

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
2	**Agricultural areas under Natura 2000**	**Share of UAA under N2K/ total UAA**	×	×	✓✓[7]	×	×	×	×	✓[8]	×
		Area of habitat types dependent on extensive agriculture under N2K	×	×	×	×	×	×	×	✓[9]	×
		Share of N2K payments/ rural development expenditure	×	×	✓ [10]	×	×	×	×	×	×
3	**Farmers' training levels and use of environmental farm advisory services**	**Number (share) of farmers having made use of environmental farm advisory services per year**	×	×	✓✓ [11]	×	×	×	×	×	×
		Share (number) of farmers having practical experience, basic training, and full agricultural training	×	×	✓✓[12]	×	×	×	×	×	×
		Share of UAA (ha) managed by farmers having practical experience, basic training, and full agricultural training	×	×	×	×	×	×	×	×	×
4	**Area under organic farming**	**Share of areas under organic farming/total UAA**	×	×	✓✓[13]	×	×	×	×	×	✓✓[14]
		Area under organic farming	×	×	✓✓[13]	×	×	×	×	×	✓✓[14]

[7] RDP - % UAA/ forest under N2K required as a baseline indicator at MS level.

[8] BHD – Area (ha) of Natura 2000 sites are required at the MS level. No information on UAA required.

[9] BHD – Area covered by each priority habitat and the main pressures impacting it are required at biogeographic region and MS level. An optional N2K assessment can be made, but the mandatory requirements are across the whole territory. This may provide relevant information for habitats impacted by agricultural pressures.

[10] RDP - Linked to RDP Measure 213, but does not require financial output data for the indicator. Measure 213 not implemented in all MS.

[11] RDP - The number of farmers using environmental farm advisory services is an output indicator of Measure 114.

[12] RDP – The share of farmers having practical experience, basic training and full agricultural training is a baseline indicator for Axis 1.

[13] RDP - where there is a measure of support under RDP funding, data on area under organic farming is required at MS level.

[14] SDI - 'Area Under Organic Farming' as share of UAA required at MS level.

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
5	**Mineral fertiliser consumption**	**Application rate of N**	×	×	×	×	✓✓[15]	✓✓[19]	×	×	×
		Application rate of P	×	×	×	×	✓[16]	×	×	×	×
		Absolute volumes of N	✓✓[17]	×	×	×	✓✓[18]	✓✓[19]	×	×	×
		Absolute volumes of P	×	×	×	×	✓[16]	×	×	×	×
		Application rate (organic fertilisers) of N	×	×	×	×	✓✓[20]	✓✓[19]	×	×	×
		Application rate (organic fertilisers) of P	×	×	×	×	✓[16]	×	×	×	×
6	**Consumption of pesticides**	**Application rates of different pesticide categories**	×	×	×	×	×	×	✓✓[21]	×	×
		Used/sold quantities of different pesticide categories	×	×	×	×	×	×	✓✓[22]	×	×

[15] ND – Annual contribution of mineral and organic forms of N (Kg/ Ha) required as part of MS action programmes.

[16] ND - Some MS have submitted this data. Not a specific requirement but may be necessary to understanding the impact of action programme measures.

[17] UNFCCC – Total use of synthetic fertiliser (kg/N/yr) required for Tier 1. For Tier 2, applications may be broken down by climate zone/ soil type.

[18] ND – Annual use of mineral and organic forms of N (kT) required as part of MS action programmes.

[19] NECD – Annual consumption of N by major N-fertiliser type, including organic N, and by land-use (arable or grassland) required.

[20] ND – For each farm, the amount of livestock manure applied to land each year including by animals themselves, should not exceed 170kg N per ha.

[21] FDSUP – Key data to be collected are the quantity (Kg) of each substance used on each crop and the area (Ha) treated with each substance.

[22] FDSUP – Sales data that will be required are the annual weight (Kg) of all active substances defined in the Regulation. Usage data as above.

INDICATOR	PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
		UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
7 Irrigation	**Share of irrigable areas / total UAA**	×	×	✓✓[25]	×	×	×	×	×	×
	Irrigable areas	×	×	×	✓[23]	×	×	×	×	×
	Irrigated areas	✓[24]	×	×	✓[23]	×	×	×	×	×
	Irrigated crop areas	✓[24]	×	×	×	×	×	×	×	×
	Irrigated area/ total UAA	×	×	✓✓[25]	×	×	×	×	×	×
	Irrigated crop area/ cropped area	✓[24]	×	×	×	×	×	×	×	×
	Share of holdings using one or more of the 3 irrigation systems surveyed in FSS	×	×	×	×	×	×	×	×	×
8 Energy use	**Total energy use at farm level in GJ per ha per year**	×	×	×	×	×	×	×	×	✓[26]
	Annual use of energy at farm level by fuel type (GJ/ha)	×	×	×	×	×	×	×	×	✓[26]
9 Land use change	**Percentage of the total agricultural area that has changed to artificial surfaces compared to a reference period**	×	✓✓[27]	×	×	×	×	×	×	✓[28]
	Land use change from agricultural land to artificial surfaces (ha)	×	✓✓[27]	×	×	×	×	×	×	✓[28]

[23] WFD – Locations of abstraction points and rates of abstraction required for pressures & impacts assessment, for which knowledge of irrigable/ irrigated areas is needed.

[24] UNFCCC – Area irrigated is required for rice crops only.

[25] RDP - Water use is required as a baseline indicator, defined as % irrigated UAA.

[26] SDI - 'Final energy consumption by sector' for agriculture sector, required by energy source in Ktoe, not in GJ/ha. Not required by farm.

[27] LULUCF – area of cropland converted to settlements is one of the reporting categories.

[28] SDI - 'Built-up areas' measured by the change in land cover over time from natural/ semi-natural to artificial surface.

INDICATOR	PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
		UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
10.1 Cropping patterns	**Share of agricultural land types/ total UAA**	✓[29]	✓✓[30]	✓[31]	×	✓✓[32]	✓✓[33]	✓✓[34]	×	×
	Area occupied by the major agricultural land types (e.g. arable crops, permanent grassland and permanent crops)	✓[29]	✓✓[30]	✓[31]	×	✓✓[32]	✓✓[33]	✓✓[34]	×	×
10.2 Livestock patterns	**Livestock density (LU/UAA)**	×	×	×	×	×	×	×	×	✓✓[35]
	Number of major livestock types (e.g. cattle, sheep, pigs, and poultry)	✓✓[36]	×	×	×	✓[37]	✓✓[38]	×	×	×
	Share of major livestock types	✓✓[36]	×	×	×	✓[37]	✓✓[38]	×	×	×
	Grazing stocking rate (grazing LU/grasslands and forage crops)	×	×	×	×	×	×	×	×	×
11.1 Soil cover	**Share of the year when the arable area is covered by plants or plant residues**	×	×	✓[39]	×	✓[40]	×	✓[41]	×	×

[29] UNFCCC – Calculation of emissions from soils, crop residue burning and rice cultivation require activity data on cropping patterns, particularly for Tier 2.

[30] LULUCF - Areas of broad land use categories in each MS are required. These include cropland and grassland.

[31] RDP – The % UAA used for extensive arable crops and grazing is required as a baseline indicator.

[32] ND – Area of permanent pasture and permanent crops, plus total agricultural land, required as part of action programmes at MS level.

[33] NECD – Calculation of emissions from soils and field burning of stubble require activity data on area of arable land and grassland, specifically including legumes, unfertilized grazed grassland, and other crop types.

[34] FDSUP – To calculate pesticide usage statistics, data on area of each crop type (incl. grassland) to which pesticides applied will be required.

[35] SDI – 'Livestock density index' calculated as number of LU per hectare of UAA.

[36] UNFCCC - Tier 1 categories are dairy cattle; non-dairy cattle; buffalo; sheep; goats; camels; horses; mules & asses; swine poultry. Tier 2 categories provide further level of detail for cattle, buffalo and swine: e.g. mature, immature, fema
males

[37] ND – MS are not required explicitly to collect data on livestock numbers, but they are necessary for calculation of manure applications to land.

[38] NECD – animal numbers, by category, collected and applied to varying level of detail across the Member States

[39] RDP - The forested and wooded land area managed primarily for soil and water protection is a baseline indicator.

[40] ND – Soil crop cover in winter is not a specific data requirement, but MS are encouraged to collect these data.

[41] FDSUP – Calculations of pesticides applications to particular crops will require temporal information on crop growth.

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
11.2	Tillage practices	**Share of arable areas under conservation or zero tillage/ total arable area**	×	×	×	×	×	×	×	×	×
		Arable areas under conservation tillage and zero tillage	×	×	×	×	×	×	×	×	×
11.3	Manure storage	**Share of manure stored in different manure storage systems**	✓✓[42]	×	×	×	✓✓[43]	✓✓[44]	×	×	×
		Share of manure applied with different application techniques and incorporation time	×	×	×	×	✓[45]	×	×	×	×
		Share of animals in different housing systems	×	×	×	×	×	×	×	×	×
12	Intensification/ extensification	**Share of low, medium, high-input farms (based on average input expenditure/UAA)**	×	×	✓[46]	×	×	×	×	×	×
		Average expenditure per ha	×	×	×	×	×	×	×	×	×
13	Specialisation	Share of the agricultural area (ha) managed by specialised farm types	×	×	×	×	×	×	×	×	×
14	Risk of farmland	Farms with farmer aged 55 years	×	×	✓✓[47]	×	×	×	×	×	×

[42] UNFCCC - default manure management systems are anaerobic lagoon; liquid system; daily spread; solid storage and drylot; pasture range and paddock; used fuel; other system. Livestock populations must be disaggregated by climate (warm, temperate, cool).

[43] ND – The type of storage used for FYM and slurry are data required as part of action programmes.

[44] NECD – Calculation of emissions from manure management require activity data on the frequency distribution of the respective manure management systems.

[45] ND – Information regarding manure application techniques may be provided by some MS as part of action programmes.

[46] RDP – areas of extensive agriculture (as % of UAA) are required as a baseline indicator.

[47] RDP – required for baseline indicator 'age structure'

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
	abandonment	FNVA/AWU per farm	×	×	✓ [48]	×	×	×	×	×	×
15	**Gross nitrogen balance**	**Potential surplus of nitrogen on agricultural land (kg N/ha/year)**	×	×	✓✓[49]	✓✓[50]	✓✓[51]	×	×	×	×
16	**Risk of pollution by phosphorus**	**Potential surplus of phosphorus on agricultural land (kg P/ha/year)**	×	×	✓✓[49]	✓✓[50]	✓[52]	×	×	×	×
		Vulnerability to phosphorus leaching/run-off	×	×	×	×	×	×	×	×	×
17	**Pesticide risk**	**Index of risk of damage from pesticide toxicity and exposure**	×	×	×	×	×	×	✓✓[53]	×	×
18	**Ammonia emissions**	**Ammonia emissions from agriculture (Ktonnes/year)**	×	×	×	×	×	✓✓[54]	×	×	×
		Share of agriculture in total ammonia emissions	×	×	×	×	×	✓✓[55]	×	×	×

[48] RDP - necessary for impact indicator on economic growth

[49] RDP – required for baseline indicator 'Water quality – gross nutrient balances'

[50] WFD - The N/P balance surplus is a commonly used indicator for identifying areas vulnerable to nutrient pollution in the pressures and impact analysis.

[51] ND – the action programmes should contain rules relating to the limitation of the land application of fertilizers based on a balance between the foreseeable nitrogen requirements of the crops, and the nitrogen supply to the crops from the soil and from fertilization. This should therefore be calculated at farm level.

[52] ND – Some MS report data on total phosphorous and orthophosphate as eutrophication parameters.

[53] FDSUP – requires that MS adopt harmonised risk indicators for pesticides, although these still under development.

[54] NECD – estimation of emissions of ammonia from the agriculture sector are made each year by MS.

[55] NECD – estimation of emissions of ammonia from all relevant source sectors are made, and the share of each sector calculated.

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
19	GHG emissions	**Greenhouse gas emissions from agriculture: (Ktonnes CO_2 equivalents/yr)**	✓✓[56]	✓✓[57]	✓✓ [58]	×	×	×	×	×	✓✓[59]
		Share of agriculture in GHG emissions	✓✓[60]	✓✓[57]	×	×	×	×	×	×	✓✓[59]
20	Water abstraction	**Share of agriculture in water use**	×	×	×	✓✓[61]	×	×	×	×	✓[62]
		Water use for irrigation (m3/year)	×	×	×	✓✓[61]	×	×	×	×	×
21	Soil erosion	**Areas with a certain level of erosion risk**	×	×	✓✓ [63]	×	×	×	×	×	✓✓[64]
		Estimated soil loss by water erosion (T/ha/year)	×	×	×	×	×	×	×	×	×
		Estimated soil loss by wind erosion (T/ha/year)	×	×	×	×	×	×	×	×	×

[56] UNFCCC – GHG emissions are reported by each Annex I Party for agricultural sources annually.

[57] LULUCF – Emissions of CO_2 from agricultural land are recorded in the cropland category. Emissions from other land-uses are also calculated.

[58] RDP – reported as the baseline indicator 'Climate change: GHG emissions from agriculture'.

[59] SDI - 'Greenhouse gas emission by sector' (including sinks)

[60] UNFCCC – GHG emissions are reported for all relevant source sectors, and the

[61] WFD – Significant water abstractions from each surface water and groundwater body by type are required to be identified. For each sub-unit or RBD, the volumes extracted per year or in different seasons by category of abstraction are required to be reported.

[62] SDI - 'Surface and groundwater abstraction as a share of available resources'

[63] RDP – data required for baseline indicator 'Areas at risk of soil erosion'

[64] SDI - 'Percentage of total land area at risk of soil erosion' ***Currently under development***

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
22	**Genetic diversity**	Number and range of crop varieties and livestock breeds	×	×	✓[65]	×	×	×	×	×	×
		Share in production of main crop varieties registered and certified for marketing	×	×	×	×	×	×	×	×	×
		Number of breeds per total livestock population for different types of livestock	×	×	✓[66]	×	×	×	×	×	×
		Distribution of risk status of national livestock breeds in agriculture	×	×	×	×	×	×	×	×	×
23	**High nature value farmland**	**Share of estimated area HNFV/total UAA**	×	×	✓✓[67]	×	×	×	×	×	×
		Estimated area HNFV	×	×	✓✓[67]	×	×	×	×	✓ [68]	×
24	**Production of renewable energy**	**Share of primary energy from crops and by-products as of total energy production**	×	×	×	×	×	×	×	×	✓✓[69]
		Production of primary energy from crops and by-products (Ktoe)	×	×	✓✓[70]	×	×	×	×	×	×
		Area of energy crops (biodiesel crops, ethanol crops and short rotation forestry)	×	×	✓✓[71]	×	×	×	×	×	×
		Renewable energy production from agriculture	×	×	✓✓[70]	×	×	×	×	×	×
		Renewable energy production from forestry	×	×	✓✓[70]	×	×	×	×	×	×

[65] RDP - Partially reported as output indicator of Measure 214 – 'Number of actions related to genetic resources'.

[66] RDP – partially reported under an output indicator of Measure 214, which requires information on the number of LU for commitments relating to the conservation of local breeds in danger of being lost to farming.

[67] RDP – should be reported under baseline indicator 'Biodiversity: High Nature Value Farmland areas' and impact indicator 'Maintenance of high nature value farming and forestry areas', although these indicators are not yet well developed.

[68] BHD Natura 2000 sites could make up part of the HNVF definition

[69] SDI - 'Share of renewables in gross inland energy consumption' using the subcategory biomass & waste.

[70] RDP – reported under baseline indicator 'Climate change: production of renewable energy from agriculture and forestry' and impact indicator 'Contribution to combating climate change'.

[71] RDP – reported for baseline indicator 'Climate change: UAA devoted to renewable energy' & impact indicator 'Contribution to combating climate change'.

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
25	**Population of farmland birds**	**Farmland bird population index**	×	×	✓✓[72]	×	×	×	×	✓[73]	✓✓[74]
26	**Soil quality**	**Agri-environmental soil quality index**	×	×	×	×	×	×	×	×	×
		Productivity: capacity of soil to agricultural biomass production	×	×	×	×	✓[75]	×	×	×	×
		Fertilizer response rate: input-need to attain optimal productivity (input change / yield increase ratio)	×	×	×	×	✓[75]	×	×	×	×
		Soil environmental quality: Carbon storage; filtering; buffering (Environmental)	×	×	×	×	✓[75]	×	×	×	×
		Production stability: the soil response to climatic variability also in relation to the organic matter stock of agricultural soils	×	×	×	×	✓[75]	×	×	×	×

[72] RDP – reported for baseline indicator 'Biodiversity: population of farmland birds'.

[73] BHD – the Birds Directive requires data on bird species listed in the annexes to the Directive present in the MS territory, although this is not consistently gathered/ reported across MS.

[74] SDI - 'Common bird index'

[75] ND – soil characteristics are reported under the ND for some MS, and may provide similar information to these parameters.

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
27.1	Water quality-Nitrate pollution	**Annual trends in the concentrations of nitrate or total oxidised nitrogen (expressed in mg/l NO3) in ground and surface water bodies**	×	×	✓✓[76]	✓✓[77]	✓✓[78]	×	×	×	×
		Share of agriculture in total nitrate pollution	×	×	×	✓✓[79]	×	×	×	×	×
		Nitrate concentration in water bodies	×	×	×	✓✓[77]	✓✓[78]	×	×	×	✓[80]
27.2	Water quality-Pesticide pollution	**Annual trend in the concentrations (µg/L) of selected pesticides compounds in ground and surface waters**	×	×	✓✓[76]	✓✓[81]	×	×	×	×	×

[76] RDP – reported under the baseline indicator 'Water quality: Pollution by nitrates and pesticides', for which annual trends in concentrations are required.

[77] WFD – the measured concentrations of nitrate in ground and surface water bodies are to be reported for each monitoring programme/ category on a regular basis.

[78] ND – concentrations of nitrate in ground and surface water monitoring sites are reported under the ND requirements. The monitoring programmes must be carried out at least every 4 years.

[79] WFD – pressures and impacts analysis will identify the most significant sources of pollution in each RBD, including agricultural sources.

[80] SDI - 'Biochemical oxygen demand in rivers' is directly related to water quality, and will be correlated with nitrate concentration.

[81] WFD – measured concentrations of priority and other substances in surface and groundwater bodies are to be reported for each monitoring programme/ category on a regular basis.

INDICATOR		PARAMETERS	Policy requirements (× = none; ✓ = partial; ✓✓ = total)								
			UNFCCC	LULUCF	RDP	WFD	ND	NECD	FDSUP	BHD	SDI
28	**Landscape - State and diversity**	Degree of naturalness	×	×	✓[82]	×	×	×	×	×	×
		Rural-agrarian landscape structure	×	×	✓[82]	×	×	×	×	×	×
		Societal appreciation of the rural-agrarian landscape	×	×	✓[83]	×	×	×	×	×	×

[82] RDP – Linked to Axis 2 payments

[83] RDP - Linked to Axis 3 payments

3.3 Task 3

The objective of Task 3 was to analyze the methodologies for calculating greenhouse gas (N_2O and CH_4) and ammonia emission and nutrient balances (nitrogen and phosphorus), with particular emphasis on the coefficients used in the calculations and the underlying data needs. Further, the objective is to identify best practices for these coefficient calculations, based on available scientific research.

Greenhouse gas and ammonia emissions from the following agricultural sources have to be calculated:

- CH_4, N_2O, and NH_3 emissions from domestic livestock;
  - CH_4 emissions from enteric fermentation;
  - CH_4 emissions from manure management;
  - N_2O emissions from manure management;
  - NH_3 emissions from manure management;
- CH_4, N_2O, and NH_3 emissions from agricultural soils (including indirect N_2O emissions).

Emissions are estimated by multiplying activity data with emission factors. Estimating emissions therefore comprises three main steps:

- Assessment of activity data;
- Assessment of emission factors – either default or country specific emission factors;
- Multiplying a specific set of activity data with specific emission factor(s).

Some basic data of livestock population characterisation are required for most of the emission estimates, i.e. information on

- livestock species and categories;
- annual population;
- milk production (needed for CH_4 emission from enteric fermentation);
- weight (needed for CH_4 emission from enteric fermentation);
- feed intake; and
- climate (needed for CH_4 emissions).

Tables 4-9 show the data required (in an ideal situation) to calculate ammonia and greenhouse emissions (see report Task 3 for more details). Tables 4 and 5 show the data relating to ammonia emission from manure management (i.e. emissions from housing, manure storage, grazing, and manure applied to the soil) and from mineral N fertilizers and organic manures applied to soils, respectively. Emissions of greenhouse gases are within the scope of the UN Framework Convention on Climate Change (UNFCCC) whereas those of ammonia are within the scope of the UN Convention on Long-Range Transboundary Air Pollution (CLTRP). Guidance on the methodologies for calculating greenhouse gas and ammonia emissions is provided in the IPCC Guidelines and the EMEP/EEA Air Pollution Emission Inventory Guidebook, respectively. In Tables 4 and 5 it is indicated if the coefficients are part of the IPPC Guidelines and UNECE Guidebook.

Tables 6-9 show the data required (in an ideal situation) to estimate the nitrogen and phosphorus balances. There are four main types of nitrogen and phosphorus balances; farm, livestock, field and soil:

- A farm balance calculates the amount of nutrient entering the farm and subtracts from it the amount of nutrient exported from the farm in agricultural products. The difference between the two represents the amount of nutrient loss to the environment, plus changes in the amount stored within the farm (principally in the soil).
- A livestock balance calculates the difference between the inputs and outputs of the livestock production system. The inputs include nutrients in imported and home-produced animal feed, and in imported bedding material. The outputs are the animal products such as fibre, meat and milk.
- A field balance calculates the difference between inputs and outputs at the field scale. Inputs include mineral fertiliser and both imported and home-produced manure (including excreta deposited during grazing). The outputs are the crop products removed by harvesting or by grazing.
- A soil balance calculates the difference between inputs and outputs across the soil surface. The components of the balance are the same as for a field balance, except that crop wastes are added to the input and the output is crop nutrient uptake rather than crop yield.

Notice that the OECD and Eurostat[84] gross N balance differs from the N soil balance, as the gross N balance considers the applied manure N equal to the excreted N on the farm, corrected for import and export of manure. In the gross N balance, no deduction is made for N losses during housing and manure storage. Thus, the surplus of the gross N balance is equal to the sum of N surplus on the soil N balance and the N losses during housing and manure storage (for arable farming systems, the soil N balance and gross N balance are equal). The gross P balance and the P soil balance are equal, as there are no gaseous losses of P from housing and manure storage.

Table 6 show the data to calculate farm N balances. Soil N balances can be constructed from the field N balances and the additional data presented in Table 7. Table 9 show the data to calculate farm P balances. The field P balances can be calculated from these farm N balances using the additional data presented in Table 10.

[84] OECD and Eurostat gross nitrogen balances handbook. (October 2007) and OECD and Eurostat gross phosphorus balances handbook. (October 2007). www.oecd.org/tad/env/indicators

Table 4: Data relating to manure management (needed for each livestock category)

Data item	Units	IPCC	UNECE	Ease	Notes
N-excretion	kg N yr^{-1}	X	X	3	National defaults available, more detailed data must be collected
C-excretion	kg C yr^{-1}	X		3	VS excretion required
Solid and liquid manure system	%	X	X	1	
Time spent grazing	hours day^{-1}	X	X	2	Ideally include seasonal distribution
Time spent on yards	hours day^{-1}	X	X	2	Ideally include seasonal distribution
Yard flooring – no leachate capture	%		X	1	Ideally indicate the surface covering (concrete, bare soil, woodchips, other)
Yard flooring – leachate capture	%		X	1	Ideally indicate the surface covering (concrete, bare soil, woodchips, other)
Amount of straw added as bedding	kg DM $head^{-1}$ yr^{-1}		X	2	
Direct spreading of manure:	%	X		2	Percentage of manure that is spread directly from animal housing to land. Ideally include seasonal distribution
Housing: fully-slatted floor	%		X	1	
Housing: partially slatted floor	%		X	1	
Housing: tied	%		X	1	
Housing: loose	%		X	1	
Housing: mech. Vent.	%		X	1	
Housing: scrubbers or biofilters	%		X	1	
Manure separation	%		X	1	Percent of manure that is separated into solid and liquid fractions
Manure to anaerobic digester (AD)	%	X		1	Should be included into UNECE as well
Supplement added to AD: Food waste	Mg yr^{-1}		X	2	
Supplement added to AD: Crop residues	Mg yr^{-1}		X	2	
Supplement added to AD: Whole crops	Mg yr^{-1}		X	2	
Slurry stored in open tanks	%		X	1	
Slurry stored in	%		X	1	

Data item	Units	IPCC	UNECE	Ease	Notes
covered tanks					
Slurry stored in lagoons	%	X	X	1	
Slurry stored in underfloor pits	%	X	X	1	
Manure stored in manure heaps	%	X	X	1	
Manure composted	%	X	X	1	
Manure incinerated	%		X	1	
Liquid manure applied to fields	%		(X)	1	Liquid manure = slurry or separated liquid fraction. Ideally include seasonal distribution
Solid manure applied to fields	%		(X)	1	Solid manure = farmyard manure or separated solid fraction. Ideally include seasonal distribution
Manure application technique: Broadcast – no incorporation	%		(X)	1	
Manure application technique: Broadcast – incorporation <2hrs	%		(X)	1	
Manure application technique: Broadcast – incorporation <1 day	%		(X)	1	
Manure application technique: bandspread	%		(X)	1	
Manure application technique: deep injection	%		(X)	1	Deep injection = > 15cm
Manure application technique: shallow injection	%		(X)	1	Shallow injection = 5-15cm

DM = dry matter

(X) = for UNECE; data needed to reliably estimate the effect of abatement measures

(X) = for soil N balance; data required to calculate manure and nitrogen applied to the soil

Ease = ease of data collection (1 = easy, 2 = moderate, 3 = difficult)

Table 5: Data related to field emissions

Data item	Units	IPCC	UNECE	Ease	Notes
Ammonium nitrate	Mg N	X	X	1	Application rate required
Ammonium sulphate	Mg N	X	X	1	Application rate required
Calcium ammonium nitrate	Mg N	X	X	1	Application rate required
Anhydrous ammonia	Mg N	X	X	1	Application rate required
Urea	Mg N	X	X	1	Application rate required
Nitrogen solutions	Mg N	X	X	1	Application rate required
Ammonium phosphates	Mg N	X	X	1	Application rate required
Organic manure	Mg N	X	X	2	Sewage sludge, municipal compost, application rate required
Immediate incorporation of urea	%		X	1	
Imported material for bedding	MG N		X	2	
Crop residue returned to field	Mg DM	X		3	
Crop residue burnt	Mg DM	X		3	Quarterly resolution needed for arctic environment/albedo effect

(X) = data required to calculate manure and nitrogen applied to the soil

Ease = ease of data collection (1 = easy, 2 = moderate, 3 = difficult)

Table 6: Data relating to farm N balances

Data item	Units	Update	Priority	Ease	Notes
Inputs					
N Fertiliser	Mg N/yr	1	High	1	
Imported manure	Mg/yr	1	High	2	To calculate nitrogen in *imported manure*
N concentration in imported manure	kg N/Mg	1	High	3	To calculate nitrogen in *imported manure*
Area of N fixing crops	ha/yr	1	High	1	To calculate *nitrogen fixation*
Fixation rate of N fixing crops	kg N/ha/yr	10	High	3	To calculate *nitrogen fixation*
Atmospheric deposition	kg N/ha/yr	1	High	1	Obtained from EMEP (www.emep.int)
Area dedicated to each crop	ha	1	Medium	1	Main cropping types. To calculate input in *seed or plants*
Sowing or planting rates	kg/ha	5	Low	2	To calculate input in *seed or plants*
N concentration in seed or plants	kg/kg	10	Low	1	To calculate input in *seed or plants*
Number of animals	Annual average population	1	High	2	To calculate N input in animal feed
Imported animal feed	Mg DM/animal	1	High	3	To calculate N input in animal feed
Concentration of N in imported feed	kg/kg DM	5	High	3	To calculate N input in animal feed
Amount of imported bedding	kg DM/animal	5	Low	3	High for straw-based animal husbandry
Outputs					
Crop products exported	Mg DM	1	High	2	Necessary to calculate N output in crop products.
Concentration of N in crop products exported	kg N/kg dry matter	10	High	2	Necessary to calculate N output in crop products
Animal products	Mg fresh weight	1	High	1	Necessary to calculate N output in animal products
Concentration of N in animal products	kg N/kg fresh weight	10	High	1	Necessary to calculate N output in animal products
Exported manure	Mg/yr	1	High	3	To calculate nitrogen in *exported manure*
N concentration in exported manure	kg N/Mg	5	High	3	To calculate nitrogen in *exported manure*

Abbreviations: DM = dry matter; Update = frequency in years with which data should be updated; Priority = priority of data for calculation; Ease = relative ease with which data can be collected on a given farm, 1 = easy, 2 = moderate, 3 = difficult

Notes: Shaded rows = data normally collected by scientific investigation;

Table 7: Additional data required for the construction of soil N balances

Data item	Units	Update	Priority	Ease	Notes
N excretion	kg/yr	1	High	2	Already required for reporting GHG and ammonia
Time spent grazing	days	5	High	3	To partition excreted nitrogen between grazed fields and animal housing. Already required for reporting GHG and ammonia
Manure spread directly from housing to fields	%	5	medium	2	Already required for reporting GHG and ammonia
Gaseous losses from animal housing	kg/yr	1	High	2	Already required for reporting GHG and ammonia
Gaseous losses from manure storage	kg/yr	1	high	2	Already required for reporting GHG and ammonia
Home-produced crop products consumed by livestock	Mg/yr	1	high	3	Difficult for grazing livestock
Concentration of nitrogen in home-produced crop products consumed livestock	kg/Mg	10	high	2	Difficult for grazing livestock
Crop products used for bedding	Mg/yr	1	medium	2	
Concentration of nitrogen in crop products use the bedding	kg/Mg	10	medium	1	
Proportion of crop mass returned to soil in residue	Mg/yr	5	high	3	Already required for reporting GHG
Concentration of nitrogen in crop mass returned to soil in residue	kg/Mg	5	high	3	Already required for reporting GHG

Abbreviations: DM = dry matter; Update = frequency in years with which data should be updated; Priority = priority of data for calculation; Ease = relative ease with which data can be collected on a given farm, 1 = easy, 2 = moderate, 3 = difficult

Notes: Shaded rows = data normally collected by scientific investigation;

Table 8: Data related to farm P balances

Data item	Units	Update	Priority	Ease	Notes
Inputs					
P Fertiliser	Mg P/yr	1	High	1	
Imported manure	Mg/yr	1	High	2	To calculate phosphate in *imported manure*
P concentration in imported manure	kg P/Mg	5	High	3	To calculate nitrogen in *imported manure*
Area dedicated to each crop	ha	1	Low	1	Main cropping types. To calculate input in *seed or plants*
Sowing or planting rates	kg/ha	5	Low	2	To calculate input in *seed or plants*
P concentration in seed or plants	kg/kg	10	Low	1	To calculate input in *seed or plants*
Number of animals	Annual average population	1	High	1	To calculate P input in *animal feed*
Animal feed	Mg DM/animal	1	High	1	To calculate P input in *animal feed*
P concentration in feed	kg/kg DM	5	High	1	To calculate P input in *animal feed*
Amount of bedding	kg DM/animal	10	Low	2	To calculate P input in *bedding.* High for straw-based animal husbandry
P concentration in bedding	kg/kg DM	10	Low	1	To calculate P input in *bedding*
Outputs					
Crop products exported	Mg DM	1	High	1	Necessary to calculate P output in *crop products*.
P concentration in crop products	kg P/kg DM	5	High	1	Necessary to calculate P output in *crop products*
Animal products	Mg fresh weight	1	High	1	Necessary to calculate P output in *animal products*
P concentration in animal products	kg N/kg fresh weight	5	High	1	Necessary to calculate P output in *animal products*
Exported manure	Mg/yr	1	High	3	To calculate P in *exported manure*
P concentration in exported manure	kg P/Mg	5	High	3	To calculate P in export*ed manure*

Abbreviations: DM = dry matter; Update = frequency in years with which data should be updated; Priority = priority of data for calculation; Ease = relative ease with which data can be collected on a given farm, 1 = easy, 2 = moderate, 3 = difficult

Notes: Shaded rows = data normally collected by scientific investigation.

Table 9: Additional data required for the construction of soil P balances

Data item	Units	Update	Priority	Ease	Notes
P excretion	kg/yr	<Annual	high		Obtain by extracting the P in animal products from P in animal feed and grazed fodder
Home-produced crop products consumed by livestock	Mg/yr	<Annual			Difficult for grazing livestock
Concentration of P in home-produced crop products consumed livestock	kg/Mg	<Annual			Difficult for grazing livestock
Crop products used for bedding	Mg/yr	<Annual			
Concentration of P in crop products use the bedding	kg/Mg	<Annual			
Crop uptake	Mg/yr	<Annual			
Crop residues returned to the soil	Mg/yr	<Annual			
Concentration of P in crop products use the bedding	kg/Mg	<Annual			

Abbreviations: DM = dry matter; Update = frequency in years with which data should be updated; Priority = priority of data for calculation; Ease = relative ease with which data can be collected on a given farm, 1 = easy, 2 = moderate, 3 = difficult

Notes: Shaded rows = data normally collected by periodic survey or scientific investigation; Italicized text = element of nitrogen balance calculation

4 Common data needs: building blocks principle

4.1 Building blocks principle

Based on the results of Tasks 1-3, an assessment is made of the common data needs for the different AEIs (see Table 2). In this table the links in data needs has been indicated. This table has been used to indentify the indicators which need the same input data. These indicators have highest priority and will be further assessed and the required data for these indicators will be described. The common data needs will be identified. In order to assess the links between AEIs in data and coefficients, the data needs of the AEIs are unravelled and "building blocks" identified.

Table 10: Cross table indicating common data needs between AEI's

Assessment of common data needs

- □ no common data need
- ▒ link in data need
- ■ strong link in data need

	5. Fertiliser	6. Pesticides	7. Irrigation	8. Energy use	11.1 Soil cover	11.2 Tillage	11.3 Manure storage	12. Int/extensification	15. N balance	16. Phosphorus	18. Ammonia	19. GHG	26. Soil quality	1. Agri commitments	2. Natura 2000	3. Farmers training	4. Organic farming	9. Land use changes	10.1 Cropping pattern	10.2 Livestock pattern	13 Specialisation	14. Farmland abandonme	17. Pesticide risk	20. Water abstraction	21. Soil erosion	22. Genetic diversity	23. High nature farmland	24. Renewable energy	25. Farmland birds	27.1 Nitrate	27.2 Pesticide	28. Landscape
5. Fertiliser	X			▒				■	■	■	■	■				▒	▒	▒	▒		▒						▒			■		
6. Pesticides	X	X		▒				■								▒	▒		▒		▒		■				▒				■	
7. Irrigation	X	X	X	▒				■			▒	▒				▒			▒		▒			■	■					■	■	
8. Energy use	X	X	X	X		■										▒			▒	▒	▒			▒				■				
11.1 Soil cover	X	X	X	X	X						▒		■		▒	▒	▒	■	■	▒	▒	■			■		■			■		■
11.2 Tillage	X	X	X	X	X	X					■	■	■			▒	▒	▒	▒			▒			■							
11.3 Manure storage	X	X	X	X	X	X	X	■	■		■	■			▒		▒			■	▒							▒		■		▒
12. Int/extensification	X	X	X	X	X	X	X	X	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	■	■	■	■	■	▒	■		■			▒
15. N balance	X	X	X	X	X	X	X	X	X	▒	■	■	▒			▒	▒	▒	▒	▒	▒									▒		
16. Phosphorus	X	X	X	X	X	X	X	X	X	X			■				▒	▒	■	■	■				■					▒		■
18. Ammonia	X	X	X	X	X	X	X	X	X	X	X	■			■	▒	▒		▒	■										■		
19. GHG	X	X	X	X	X	X	X	X	X	X	X	X				▒	▒	■	■	■	■							■		▒		
26. Soil quality	X	X	X	X	X	X	X	X	X	X	X	X	X		▒		■	■	■			▒			■		▒			▒		▒
1. Agri commitments	X	X	X	X	X	X	X	X	X	X	X	X	X	X	■											▒						
2. Natura 2000	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		▒			▒	▒	▒	▒				■		■			▒
3. Farmers training	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	▒		▒	▒	▒		▒		▒					▒	▒	▒
4. Organic farming	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	▒	■	■	■	■	■		▒		▒		▒	▒	▒	▒
9. Land use changes	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		■	■	■					▒	▒	▒	▒	▒	■
10.1 Cropping pattern	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	■	■	▒	■	■	■	▒	▒	■	■	■	■	■
10.2 Livestock pattern	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	■						■			■		■
13 Specialisation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		■			▒	■					▒
14. Farmland abandonment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	▒	▒	▒	▒	▒		▒	▒	▒	▒
17. Pesticide risk	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	■							■	
20. Water abstraction	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	▒					■	■	
21. Soil erosion	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					▒	▒	■
22. Genetic diversity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	▒		▒			
23. High nature farmland	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		■			■
24. Renewable energy	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				■
25. Farmland birds	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			■
27.1 Nitrate	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
27.2 Pesticide	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
28. Landscape	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Two types of building blocks can be distinguished, namely those for (i) primary activity data and (ii) for coefficients (e.g. excretion factors and emission factors). Here, coefficients are defined as “factors or parameters which can are not be derived directly from statistical surveys, and therefore have to be derived or assessed indirectly” (from e.g. measurements, scientific reports and papers or from simulation modelling). Evidently, estimation of coefficients requires approved protocols and transparent verification procedures.

The building blocks for the required primary activity data for the priority AEIs can be grouped in the following categories:

- Inputs
  - Nutrients
  - Pesticides, water, energy
- Land cover
- Crop production
- Livestock production
- Management
  - Livestock
  - Farm
- Soil and water quality

Notice that the activity data required for air quality (NH_3, CH_4, N_2O, CO_2) are also covered by these categories. Therefore, no specific category and building blocks for activity data for air quality needs to be made.

The results of Tasks 1-3 have been used to identify the required data for the 1st set of parameters AEIs. Figure 2 shows the required activity data for the different categories in the ideal system of data collection. These data can be considered as the building blocks. The building blocks can be used for (calculation of) the different indicators, as indicated in Figure 2.

4.2 Common data need for Agri-Environmental Indicators

There are clear differences in data needs between the AEIs (see Table 11). Some of the indicators are directly based on one or a limited number of data and coefficients (e.g. the use of N fertilizer). However, other AEIs have to be calculated from (large) sets of data and coefficients (e.g. N balance, ammonia emission and greenhouse gas balance).

Figure 3A shows the need for primary data to estimate the different AEIs in the ideal situation and Figure 3B the needed coefficients. These Figures are based on the results of Tasks 1-3. Clearly, there is a large overlap in the need for data in some of the AEIs, and especially the AEIs related to fertilizer and manure (N balance, ammonia emission, and greenhouse gas emissions). Moreover, all of these AEIs also include the AEIs N fertilizer consumption and manure storage and are related to the AEI Risk of P pollution. The AEIs irrigation, soil cover, tillage practice, and soil quality are also related to yields, N balances, and risk of N and P emissions. This points at clear potential for common data collection for many of the first set of indicators. In the Chapter 5, these AEIs are analyzed in more detail in order to derive a scenario for common data collection.

In the Figures building blocks of the same size are indicated. However, building of different sizes can be used as a type of Tier approach. The smaller blocks are data on a detailed level (Tier 3), whereas the bigger blocks are the data at a higher scale. For example, the total mineral fertilizer consumption in a country can be considered as a big block (Tier 1), whereas the use of calcium ammonium nitrate fertilizer on a farm can be considered as a small block (Tier 3). Such a Tier approach on building blocks is not further developed in this report, but can be a tool when the data collection of specific AEIs should be unravelled in detail in order obtain insight in possible potentials for common data collection.

Table 11: Type of data required for the different AEIs in the 1st set of AEIs

AEI		Source of required data	Data
5	Mineral fertiliser consumption	Directly derived from one or a limited number of parameters	Use of N and P fertilizers
6	Consumption of pesticides	Directly derived from one or a limited number of parameters	Use of each pesticide
7	Irrigation	Directly derived from one or a limited number of parameters	Share of irrigation
8	Energy use	Directly derived from one or a limited number of parameters	Energy consumption
11.1	Soil cover	Directly derived from one or a limited number of parameters	Crop area, winter crops
11.2	Tillage practices	Directly derived from one or a limited number of parameters	Areas with conservation, zero and conventional tillage
11.3	Manure storage	Directly derived from one or a limited number of parameters	Type of manure storage
12	Intensification/ extensification	Directly derived from one or a limited number of parameters	Inputs of pesticides, fertilizer, livestock number, farm type, yields
15	Gross nitrogen balance	Calculation from a set of parameters	Crop area, livestock numbers, fertilizer consumption, manure application, atmospheric deposition, crop yields
16	Risk of pollution by phosphorus	Calculation from a set of parameters	Soil properties, crop yield, crop area, P excretion, livestock number, P fertilizer use
18	Ammonia emissions	Calculation from a set of parameters	N fertilizer use, irrigation, livestock number, N excetion, housing, manure storage type and time, manure application technique, grazing days, manure treatment
19	Greenhouse gas emissions	Calculation from a set of parameters	N fertilizer use, livestock number, N and C excetion, housing, manure storage type and time, manure application technique, grazing days, manure treatment, crop residue, tillage
26	Soil quality	Directly derived from one or a limited number of parameters	Soil properties

Figure 2: Possible building blocks for activity data for agri-environmental indicators (first set of indicators)

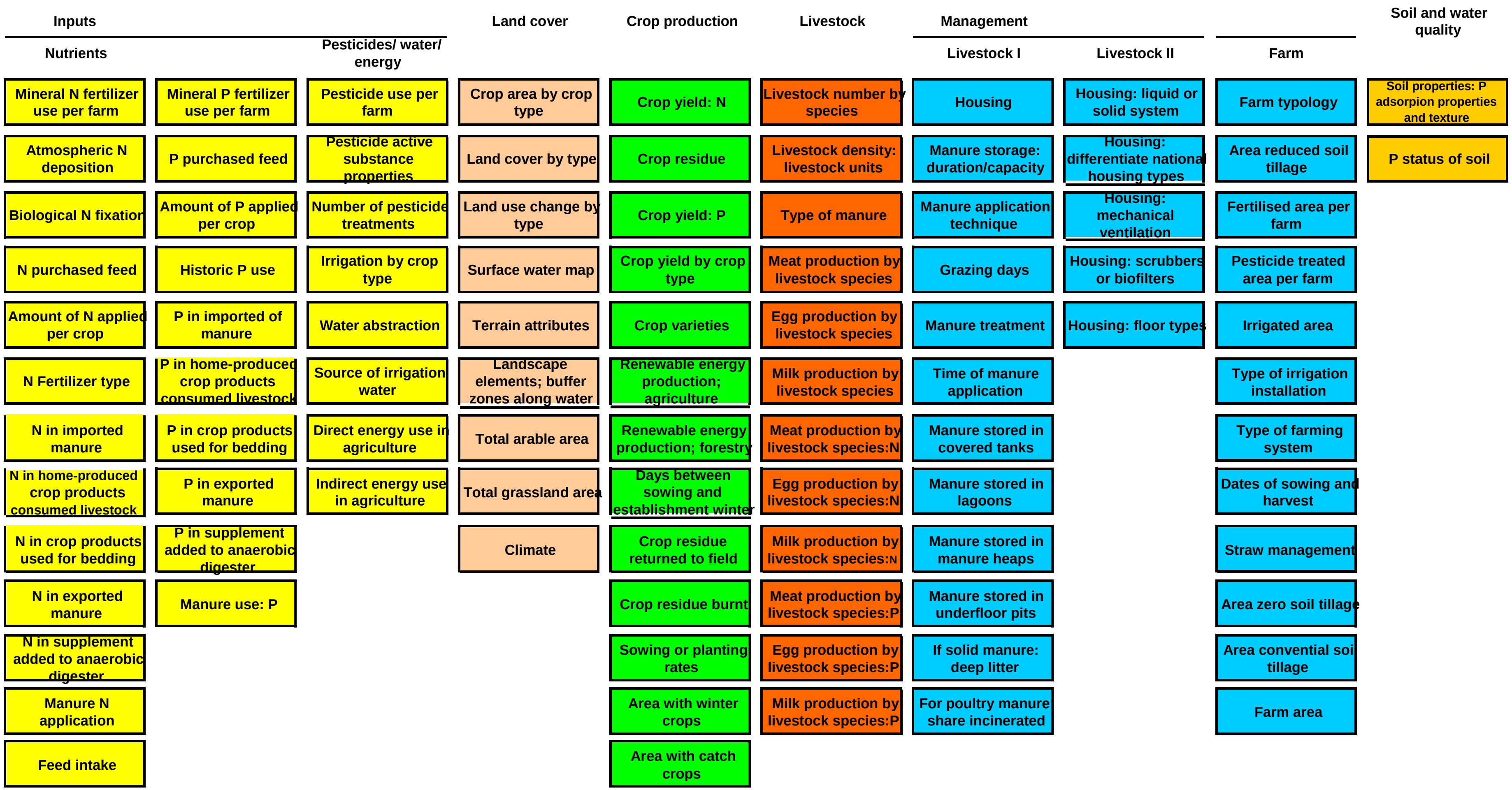


Figure 3A: Activity data required for the different AEIs*
Synthesis of Tasks 1-3, showing the ideal data collection (Part I)

Mineral fertiliser consumption	Consumption of pesticides	Irrigation	Energy use	Soil cover
Mineral N fertilizer use per farm	Pesticide use per farm	Irrigation by crop type	Direct energy use in agriculture	Crop area by crop type
Mineral P fertilizer use per farm	Pesticide active substance properties	Water abstraction	Indirect energy use in agriculture	Land cover by type
Amount of P applied per crop	Number of pesticide treatments	Source of irrigation water	Type of farming system	Area with winter crops
Amount of P applied per crop	Pesticide treated area per farm	Type of irrigation installation	Farm area	Crop residue
Amount of N applied per crop			Livestock number by species	Days between sowing and establishment winter crop
			Crop area by crop type	Area with catch crops
			Area with catch crops	Crop residue returned to field
				Crop residue burnt

*See figure 2 for explanation of colours

Figure 3A: Activity data required for the different AEIs*
Synthesis of Tasks 1-3, showing the ideal data collection (Part II)

Tillage practices	Manure storage	In/extensification	Gross nitrogen balance	Risk of pollution by phosphorus
Area reduced soil tillage	Housing	Purchased feed	Mineral N fertilizer use per farm	Amount of P applied per crop
Area zero soil tillage	Manure storage: duration/capacity	Pesticide use	Atmospheric N deposition	Mineral P fertilizer use per farm
Area convential soil tillage	Grazing days	N fertilizer use	Biological N fixation	Manure use: P
	Manure treatment	Livestock number by species	Purchased feed	P purchased feed
	Time of manure application	Meat production by livestock species	Manure N application	Historic P use
	Manure stored in covered tanks	Egg production by livestock species	N in imported manure	P in imported of manure
	Manure stored in lagoons	Milk production by livestock species	N in home-produced crop products consumed livestock	Pin home-produced crop products consumed livestock
	Manure stored in manure heaps	Crop yield	N in crop products used for bedding	P in crop products used for beddin g
	Manure stored in underfloor pits		N in exported manure	P in exported manure
	If solid manure: deep litter		N in supplement added to anaerobic digester	P in supplement added to anaerobic digester
	For poultry manure: share incinerated		Meat production by livestock species: N	Surface water map
	Housing: liquid or solid system		Egg production by livestock species: N	Terrain attributes
	Type of manure		Milk production by livestock species: N	Crop area by crop type
			Crop yield: N	Area with winter crops
				Area with catch crops
				Meat production by livestock species: P
				Egg production by livestock species: P
				Milk production by livestock species: P
				Crop yield: P
				Phosphorous concentration in water
				P status of soil
				Soil properties: P adsorpion properties and texture
				Estimated soil loss by water erosion

*See figure 2 for explanation of colours

Figure 3A: Activity data required for the different AEIs*
Synthesis of Tasks 1-3, showing the ideal data collection (Part III)

Ammonia emissions	Greenhouse gas emissions		Soil quality
	Nitrous oxide emission	Methane emission	not properly defined
Mineral N fertilizer use per farm	Mineral N fertilizer use per farm	Feed intake	
N Fertiliser type	N Fertiliser type	Manure treatment	
N in importedmanure	N in importedmanure	Grazing days	
N in exported manure	N in exported manure	Manure storage: duration/capacity	
N in supplement added to anaerobic digester	N in supplement added to anaerobic digester	Manure storage: type	
Manure N application	Manure N application	Housing	
Housing	Housing	Livestock number by species	
Manure storage: duration/capacity	Manure storage: duration/capacity	Climate	
Manure application technique	Manure application technique		
Grazing days	Grazing days		
Manure treatment	Manure treatment		
Time of manure application	Time of manure application		
Manure stored in covered tanks	Manure stored in covered tanks		
Manure stored in lagoons	Manure stored in lagoons		
Manure stored in manure heaps	Manure stored in manure heaps		
Manure stored in underfloor pits	Manure stored in underfloor pits		
If solid manure: deep litter	If solid manure: deep litter		
For poultry manure: share incinerated	For poultry manure: share incinerated		
Housing: liquid or solid system	Housing: liquid or solid system		
Housing: differentiate national housing types	Housing: differentiate national housing types		
Housing: mechanical ventilation	Housing: mechanical ventilation		
Housing: scrubbers or biofilters	Housing: scrubbers or biofilters		
Housing: floor types	Housing: floor types		
Crop area	Crop area		
Livestock number by species	Livestock number by species		
	Crop residue		

Figure 3B: Building blocks coefficients required for the different AEI's

Mineral fertiliser consumption	AEI Consumption of pesticides	AEI Gross nitrogen balance	AEI Risk of pollution by phosphorus	AEI Ammonia emissions	AEI Greenhouse gas emissions	
					Nitrous oxide emission	Methane emission
mineral N application rate per crop	pesticipe application rate per crop	N excretion	P excretion	N excretion	N excretion	Methane emission factor enteric fermentation
		Ammonia emission factor: housing	Harvested crop yield	TAN excretion	TAN excretion	C excretion
		Ammonia emission factor: manure storage	P content harvested crop	Ammonia emission factor: housing	Ammonia emission factor: housing	
		Nitrous oxide emission factor: housing		Ammonia emission factor: manure storage	Ammonia emission factor: manure storage	
		Nitrous oxide emission factor: manure storage		Ammonia emission factor: applied manure	Ammonia emission factor: applied manure	
		Denitrification emission factor: housing		Ammonia emission factor: grazing	Ammonia emission factor: grazing	
		Denitrification emission factor: manure storage		Ammonia emission factor: mineral N fertilizer	Ammonia emission factor: mineral N fertilizer	
		Harvested crop yield			Nitrous oxide emission factor: housing	
		N content harvested crop			Nitrous oxide emission factor: manure storage	
					Nitrous oxide emission factor: applied manure	
					Nitrous oxide emission factor: grazing	
					Nitrous oxide emission factor: mineral N fertilizer	
					Nitrous oxide emission factor: crop residue	
					Indirect nitrous oxide emission factor: leaching	
					Indirect nitrous oxide emission factor: ammonia emission	
					Leaching factor	

4.3 Common data need for policies

The ‘building block’ approach was also applied in Task 2 to assess which policies have most data requirements in common with the AEIs. In many cases, the data (as required by the AEI) are only partially fulfilled by the policy requirement (e.g. crop area data may only be required for a subset of crops). In Task 2 it was concluded that the coverage of AEI coefficients within each building block category across policies can be summarised as follows:

Inputs: Most of the input data that are also needed for policy are represented under the policies that require the calculation of pollution levels from agriculture – namely UNFCCC; WFD; Nitrates Directive; National Emissions Ceiling Directive; and Framework Directive on the Sustainable Use of Pesticides. This group of coefficients is also represented under RDP and SDI, however this data is usually collected from other existing sources.

Land cover: Data on land use and nature are well represented under RDP; LULUCF; Birds & Habitat Directives; and SDI. Crop area features across a number of policies.

Crop production: The crop production data that are needed for policy are represented under the policies that require calculation of pollution or emissions from crop production: UNFCCC; LULUCF; and Nitrates Directive. The renewable energy production parameter also features under RDP and SDI.

Livestock: Similarly, livestock data are required under policies that calculate pollutants from livestock: UNFCCC; Nitrates Directive and NECD.

Farm management: The type of manure storage is data commonly collected for policy purposes, specifically UNFCCC; Nitrates Directive and NECD. A soil tillage parameter is also required for the latter two. Data on farmer training and diversification is also collected under RDP.

Soil and water quality: Soil data is fairly sparsely collected for policy, the most significant being under the Nitrates Directive. Soil coefficients are well represented under SDI, but do not necessarily exactly match the AEI coefficients. Water quality is the ultimate reporting requirement of WFD and Nitrates Directive. These data are collected from other sources for RDP and SDI as indicators.

Figure 4 provides a consolidated summary of the data requirements of AEIs and policy relating to agriculture and the environment. The policies collecting data applicable to SDIs are stacked above the parameter, and ranked in order of the coverage available.

Figure 4: A building block diagram showing the policies that require data applicable to each of the AEIs

The block is intersected if the data requirement for the AEI is not fully met by data collected for the policy (Figure 2 Task 2).

5 Conceptual schemes for common data collection

5.1 Agri-Environmental Indicators related to fertilizers and manures

In the previous Chapter it is indicated that there is potential for common, harmonized, data collection for the AEIs related to nitrogen and phosphorus balances and ammonia and greenhouse gas emissions (see Figure 5):

- AEI 15. *Gross nitrogen balance*;
- AEI 18. *Ammonia emission*;
- AEI 19. *Greenhouse gas emissions (N_2O and CH_4)*;
- AEI 5. *Mineral fertilizer consumption*;
- AEI 11.3. *Manure storage;*
- AEI 16. *Risk of pollution by phosphorus;*
- AEI 11.1. *Soil cover*;
- AEI 7. *Irrigation;*
- AEI 11.2. *Tillage practice*, and
- AEI 26. *Soil quality*.

Moreover, in the second set of indicators, there are some indictors which also have a relation to nitrogen and phosphorus balances and ammonia and greenhouse gas emissions, i.e. AEI 21 *Soil erosion* (related to risk of *pollution by phosphorus*), AEI 10.2 *Livestock pattern*, AEI 10.1 *Cropping pattern*, and AEI 27.1 *Nitrate pollution* (water quality).

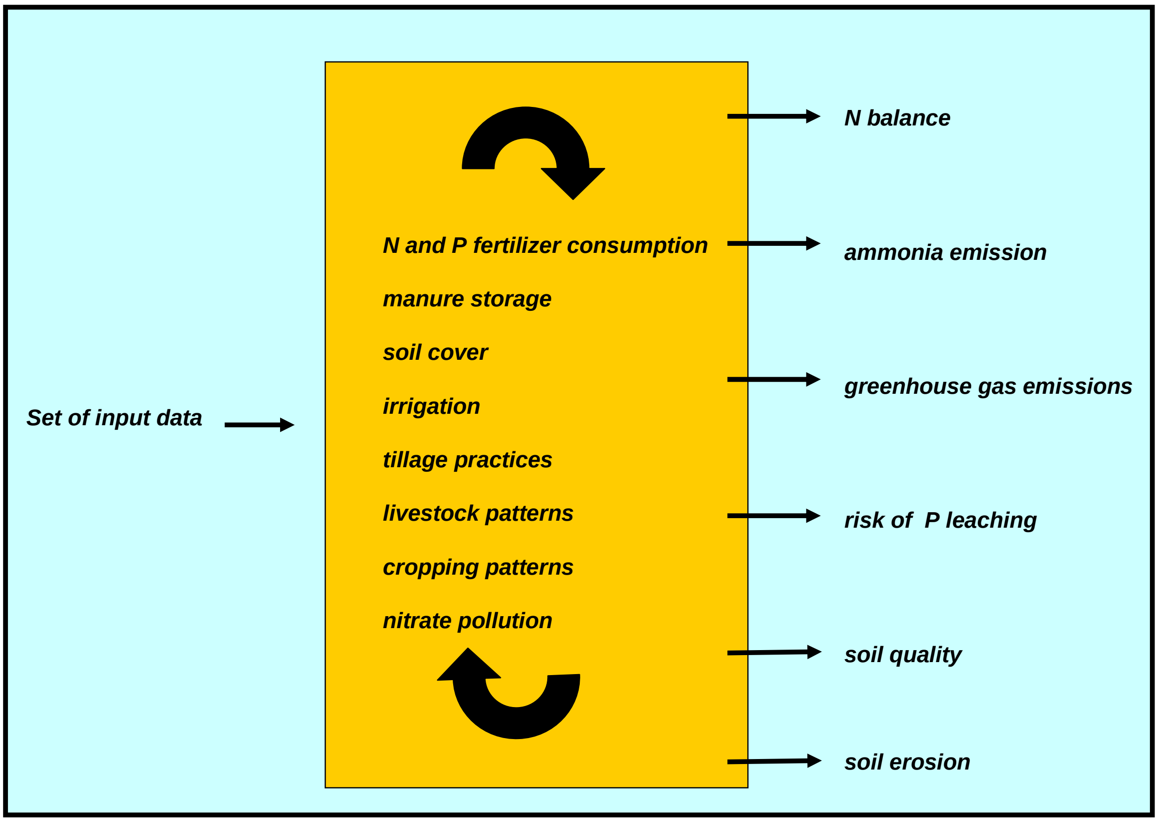
Part of the data needed for the estimation of these AEIs have to be collected via surveys, while the needed coefficients have to be derived from various data sources, including those from surveys (Figure 5).

In this paragraph, conceptual schemes are presented, which show how to obtain the data needed for the AEIs indicated in Figure 5. These schemes include:

1. Schemes and descriptions of N and P flows and their emissions to the environment in a farming system;
2. Schemes showing the positioning of the AEIs in the farming systems. Further, the (calculation) steps are defined to obtain all data and coefficients needed for the AEIs in this scheme.
3. Finally, the AEIs which are not covered by this scheme are analyzed in terms of data needs and grouped, in order to harmonize data collection.

A detailed assessment of the data requirements is made in Chapter 7

Figure 5: Schematic scheme for common data collection for AEIs Gross N (and P) balances, ammonia emission, greenhouse gas emissions (N_2O and CH_4), N and P fertilizer consumption, manure storage, soil cover, risk of pollution by phosphorus, irrigation, tillage practice, soil quality, soil erosion, livestock pattern, cropping pattern, and nitrate pollution



The AEIs in the yellow box are AEIs that can be derived directly from surveys and statistics. The AEIs on the right side of the Figure have to be derived on the basis of (various) data and coefficients (including other AEIs).

5.2 Nitrogen and phosphorus flows in farming systems

The nitrogen (N) and phosphorus (P) flows in farming systems are schematically presented in Figure 6. The box can be considered as a farm, but also as a region or country. Within the farm or region, various components are distinguished (soil, crop, livestock, manure storages). Arrows indicate the input into and output of N (upper figure) and P (lower figure) out of the farming system (delineated by the outer box). In addition, there are various internal flows. A short description is given below, starting with livestock.

The N excretion of livestock within the farming systems is controlled by the type and number of animals, the type and composition of animal feed, the production of meat, milk, and eggs, and changes in animal weight. The feed can be imported (from an other farm, region, or country) or produced in the system. Part of the N is excreted directly on grassland during grazing by e.g. (dairy) cattle, sheep, goat, and horses. Part of the N is excreted in housing systems and collected as manure. The type of manure storage affects the composition of manure (liquid or solid) and the gaseous N emissions from stored manure (ammonia, nitrous oxide, and dinitrogen) and N leaching during storage. In some cases, the manure is exported from the farm, region or country (sometimes after manure treatment). In the latter case, the emissions related to the production and storage of manure (e.g. N emissions from stored manure) have to be considered, but not the emissions related to the application of the manure to soils.

The manure application to soil can be carried out by different methods (from broadcast surface spreading to deep injection). The N of the manure enters the soil and (part of) this can be used by the crop. In addition to manure, also mineral N fertilizer, biological N fixation, and atmospheric deposition are sources of N added to the soil, which can be used by the crop. For most crops only the harvested part of the crop is removed from the field; crops residues will be returned to the soil. Thus, the total crop uptake of N is higher than the N removed from the field as harvested product. The N in the crop residue can be transformed into mineral N in the soil (mineralisation of organic N). The N released can be used by the next crops, or can be lost by leaching or gaseous emissions. Part of the N in crop residues remain in the soil as organic N.

The N surplus on the soil balance is calculated as the difference between all N inputs (grazing, applied manure, N fertilizer, atmospheric deposition, and biological N fixation) and the N removed by crop products. The fate of the N surplus is dependent on weather and soil conditions, but can divided in

1. the N that is left in the soil as organic and/or mineral N,
2. the N that is emitted as gas to the atmosphere by ammonia emission and/or denitrification (with dinitrogen and nitrous oxide as end products), and/or
3. the N that is lost to groundwater and/or surface waters via leaching and overland flow (run off).

In addition to N losses from the soil, also N will be lost from manure collected in housing systems and stored in manure storage systems.

The N surplus on the farm balance (or farm gate balance) can be calculated from the difference between the N inputs via feed, mineral N fertilizer, biological N fixation, and atmospheric deposition, and the N outputs via exported animal and crop products and export of manure. All N flows within the system, such as the fodder produced and consumed in the system, are not considered in the farm gate balance.

The scheme with P flows in a farming system is rather similar to the scheme for N flows (Figure 6), except for the facts that there are no gaseous emissions of P and there is not much P input via atmospheric deposition. A major difference between N and P is that P the P surplus on the P balance largely accumulates in the soil. In contrast, most of the N surplus will be lost to the atmosphere and groundwater and surface waters.

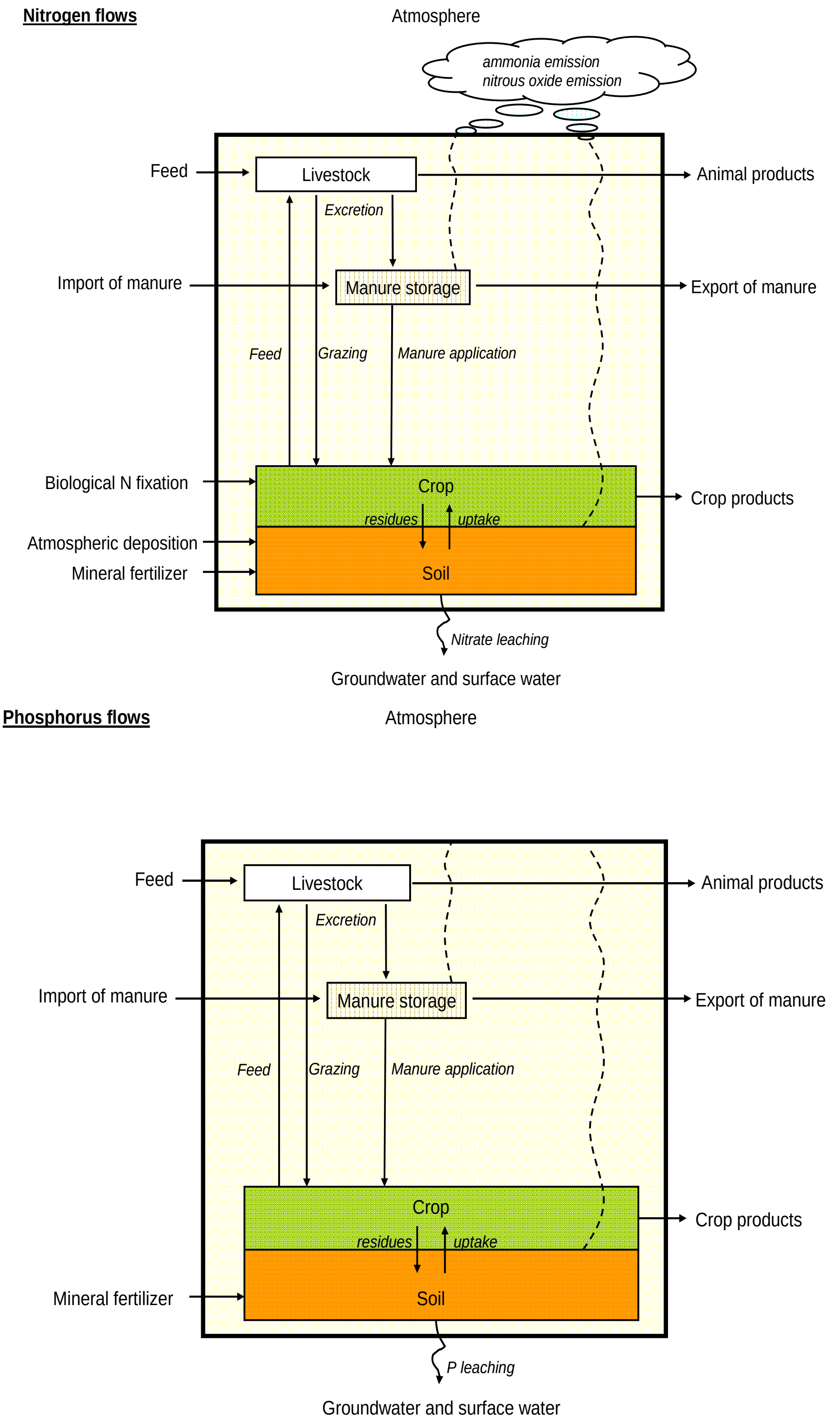
Notice that the OECD and Eurostat[85] gross N balance differs from the N soil balance, as the gross N balance considers the applied manure N equal to the excreted N on the farm, corrected for import and export of manure. In the gross N balance, no deduction is made for N losses during housing and manure storage. Thus, the surplus of the gross N balance is equal to the sum of N surplus on the soil N balance and the N losses during housing and manure storage (for arable farming systems, the soil N balance and gross N balance are equal). The gross P balance and the P soil balance are equal, as there are no gaseous losses of P from housing and manure storage.

Agricultural systems are also an important source of the non-CO_2 greenhouse gases nitrous oxide and methane. Emissions of nitrous oxide from soils and manure storage systems are included in the scheme of N flows. There are two sources of methane in agricultural systems, i.e. enteric fermentation of ruminants and storage of manure.

[85] OECD and Eurostat gross nitrogen balances handbook. (October 2007) and OECD and Eurostat gross phosphorus balances handbook. (October 2007). www.oecd.org/tad/env/indicators

Figure 6: Schematic overview of N (upper figure) and P (lower figure) flows in farming systems

The box in each figure can be considered as farm, region or country. Notice that the total N2 losses by denitrification are not indicated in the Figure, as these losses are not covered by AEIs.



5.3 Data collection for estimating nitrogen and phosphorus flows

In Figure 7 the AEIs related to and depending on N and P flows and emissions of ammonia and greenhouse gases are positioned in the scheme. The AEIs are divided in AEIs that can be derived estimated directly on the basis of data collected in surveys and from statistics and AEI that have to be calculated on the basis of data and coefficients.

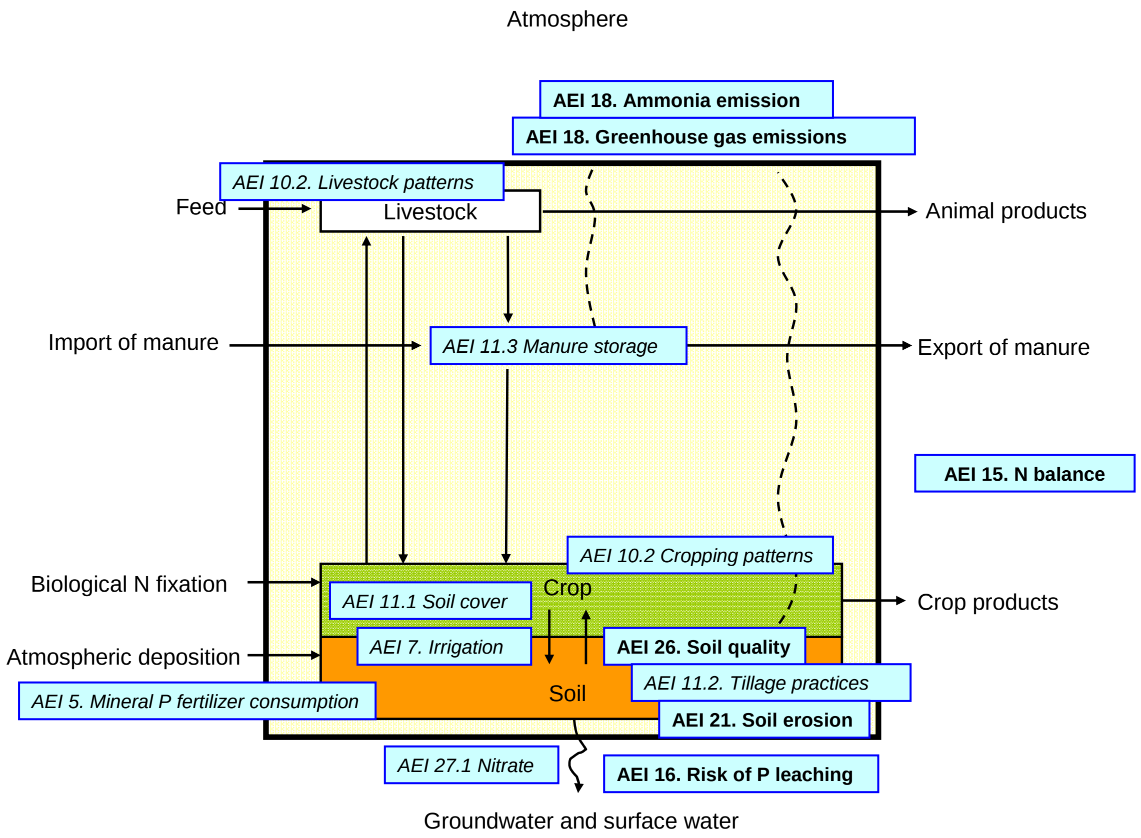
The AEIs that can be derived directly from data collected in surveys and from statistics are

- AEI 5 *Mineral fertilizer consumption*. This indicator is also needed to calculate N and P balances, ammonia emission, and greenhouse gas emissions.
- AEI 11.3 *Manure storage*. This indicator is also needed to calculate ammonia and greenhouse gas emissions.
- AEI 11.1 *Soil cover*. This indicator is also needed to calculate the N and P removal by harvested crops in the N and P balance and can be used for assessment of risk of pollution by phosphorus and erosion.
- AEI 10.1 *Cropping pattern*. This indicator is also needed to calculate the N and P removal by harvested crops in the N and P balance and can be used for assessment of risk of pollution by phosphorus and erosion.
- AEI 7 *Irrigation.* This indicator can also be used for estimate of the crop yield and for assessment of risk of pollution by phosphorus and erosion.
- AEI 11.2 *Tillage practice*. This indicator can also be used for assessment of risk of pollution by phosphorus and erosion, and for the soil quality indicator.
- AEI 10.2 *Livestock pattern*. This indicator is also needed to calculate the N and P excretion by livestock.
- AEI 27.1 *Nitrate pollution* (measured water quality).

The AEIs that have to be calculated using data (which may include other AEIs) and coefficients are

- AEI 15 Gross *N balance*;
- AEI 18 Ammonia emission;
- AEI 19 Greenhouse gas emissions (N_2O and CH_4);
- AEI 16 *Risk of* pollution by phosphorus;
- AEI 26 Soil quality;
- AEI 21 Soil erosion.

Figure 7: AEIs positioned in the scheme with N and P flows and emissions of greenhouse gases



The AEIs are indicated as the grey boxes. AEIs which can be directly collected from surveys and statistics are indicated with a italic letter type and the AEIs that have to be calculated are indicated with a bold letter type.

Based on Figures 6 and 7 a calculation scheme has been set up with steps for data collection and processing so as to derive all the AEIs discussed in this chapter. The aim of this calculation scheme is to set up of systematic approach to collect data and coefficients and to harmonize data collection and processing (data and coefficients) that have to be used for different AEIs. A calculation scheme with 12 steps has been set up (see Figure 8).

Step I. Calculate the total annual N and P excretion by livestock during grazing and in housing. The excretion of carbon may be included if factor this needed for calculating methane emissions from manure storage.

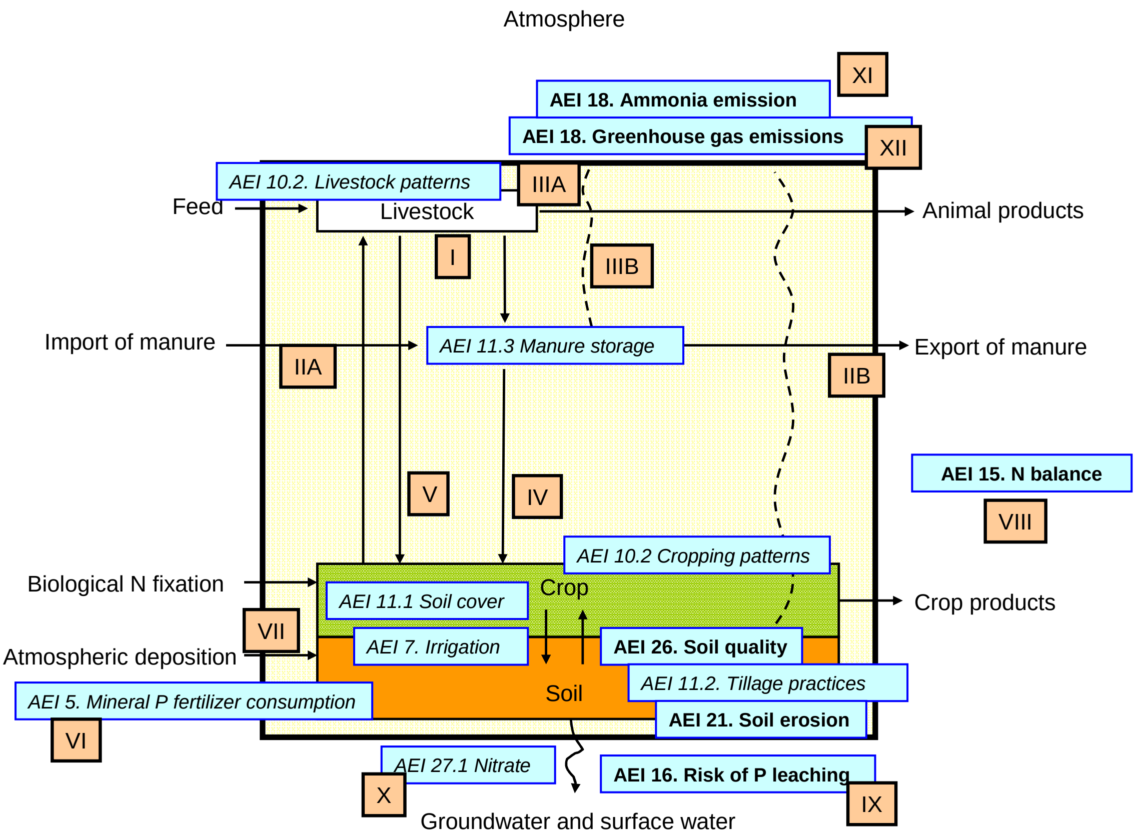
Required data:

- The number of livestock per category.
- The N, P and C excretion per animal category per year. This can be derived from default values or calculated using data of the type and amount of feed consumed and the production of meat, milk, eggs (see Report of Task 3 and Chapter 6 for more a detailed description of the methods to derive excretion of livestock).
- The portion of the manure excreted in housing and during grazing (calculated from housing/grazing days).

In this step, the data for the AEI 10.2 *Livestock pattern* have to be collected.

Figure 8: Scheme with calculations steps for data collection and processing to estimate the AEIs related to emissions of N and P balances and emissions of ammonia and greenhouse gases

The steps (Roman numbers in boxes) are explained in the text.



Step II. Calculate the amounts of N and P imported (IIA) and/or exported (IIB) as manure.

Required data:

- Export and import of manure per year and the contents of N and P of this manure.

Step III. Calculate the gaseous emissions from livestock (IIIA), housing and manure storage (IIIB) per year: N_2O, NH_3, and CH_4. In order to calculate the amount of N that is transported from manure storage to the field, also the N_2 emission has to be calculated.

III A. Calculate the CH_4 emission from enteric fermentation.

Required data.

- Minimum data requirements: type of livestock, emission factors for CH_4.

III B. Calculate the N_2O, NH_3, and CH_4 emissions from housing and manure storage per year.

The emissions are dependent on the type of manure storage. For example, factors as type of manure (slurry/solid), duration of manure storage, mixing of manure with other compounds (cleaning water, rain and drainage water from hard surfaces, bedding materials, products for digestion, etc.), covering manure storage, and temperature (period) of manure storage affect gaseous emissions from manure storage.

Required data:

- Amount of stored manure, expressed in mass of N and C (derived from the calculations in Steps I and II) per year,
- Emission factors for NH_3, N_2O, N_2, and CH_4 dependent of type of housing,

In this step, the data for the AEI 11.3 *Manure storage* have to be collected and part of the emissions for the AEI 18 *Ammonia emission* and AEI 19 *Greenhouse gas emission* are obtained (the emissions from soils have to be added to the emission from livestock, housing and manure storage to obtain the total ammonia and greenhouse emissions.

Step IV. Calculate the amounts of manure N applied to the soil, and the associated emissions of NH_3 and N_2O.

The emissions are dependent of the manure application method and type of manure.

Required data:

- Amount of N applied as manure per year, divided over crop and grassland areas. The amount of N applied is calculated as: the amount of excreted N and P in housing - the export of manure N and P + the import of manure N and P – gaseous N emissions from housing and storage ($NH_3 + N_2O + N_2$).
- Emission factors for NH_3 for different application techniques, and if available for soils and crops.

In this step, the data for the AEI 10.1 *Cropping pattern* and AEI 11.1 *Soil cover* have to be collected, and some emissions related to AEI 18 *Ammonia emission* and AEI 19 *Greenhouse gas emission* are calculated.

Step V. Calculate the amounts of N and P excreted during grazing, and the associated emissions of NH_3 and N_2O.

Required data:

- N and P excretion (result of calculation in Step II) during grazing per year,
- Grassland area, and
- Emission factors for NH_3 and N_2O.

In this step, the data for the AEI 10.1 *Cropping pattern* and AEI 11.1 *Soil cover* have to be collected and part of the emissions for the AEI 18 *Ammonia emission* and AEI 19 *Greenhouse gas emission* are calculated.

Step VI. Calculate the amounts of N and P applied as N and P fertilizer, and the emissions of NH_3 and N_2O associated with N fertilizer use.

Data on the application of nitrogen and phosphorus via mineral fertilizers per crop are needed, in kg per ha per year. For the supporting indicators, the total amounts of nitrogen and phosphorus applied per crop, in kg per ha per year, and the amounts of nitrogen and phosphorus via organic fertilizers per crop are needed, in kg per ha per year. Manure N application has to be calculated from the N excretion, corrected for gaseous N losses in housing and storage, and the import and export of manure N (Steps I-IV). The available amount of manure has to be divided over the crops using regional-specific expert knowledge and knowledge about farming systems.

The emissions are dependent of the type of N fertilizer. Data of soil cover (area grassland, fodder crops and arable crops) are needed to calculate the application rates per ha.

Required data:

- Amounts of N and P fertilizer use per year,
- Crop and grassland areas (soil cover), and
- Emission factors for NH_3 and N_2O for different types of N fertilizers.

In this step, the data for the AEI 5 *Mineral fertilizer consumption* have to be collected. The data of AEIs 10.1 *Cropping pattern* and 11.1 *Soil cover* are used for application rates per crop.

Step VII. Calculate the N inputs via biological N fixation and atmospheric N deposition and related N_2O emissions

Required data:

- Biological N fixation
- Atmospheric N deposition
- In this step, the data of AEIs 10.1 *Cropping pattern* and 11.1 *Soil cover* are used.

Step VIII. Calculate the Gross N balance

Required data for Gross N balance and the soil N balance:

N inputs

- Manure N applied (**Step IV**). For the soil N balance, the gaseous N losses during housing and from manure stored has to be extracted from the N excretion, so as to estimate the actual amount of N applied.
- N excreted during grazing (**Step V).**
- Mineral N fertilizer application (**Step VI**).
- Biological N fixation (**Step VII).**
- Atmospheric N deposition (**Step VII).**

N outputs:

- N removed by harvested crop products (yields), calculated from the yields and N contents of the harvested products per year, cropping patterns (including catch crops and winter crops; soil cover) and grassland area. The AEI 7 *Irrigation* can be used to estimate the yield. The share of irrigable areas in the total area used for agriculture (main indicators) and for supporting indicators information about irrigated areas, irrigated crops, and, irrigation methods have to be included.

The surplus of the AEI 15 *Gross N balance* is calculated as the difference between total N inputs and total N outputs.

In this step, the data of AEIs 10.1 *Cropping pattern* and 11.1 *Soil cover* are used and those of AIE 7 *Irrigation* can be used.

Step IX. Calculate the risk of pollution by phosphorus.

The risk of pollution by phosphorus is calculated as the P surplus on the P balance, i.e. the difference from the P inputs via i) mineral fertilizer, ii) manure, and iii) grazing and the P output via crop removal, including the P removed by cut or grazed grass. This is the main indicator. The vulnerability to phosphorus leaching and run-off is a supporting indicator. A method to quantify the vulnerability to phosphorus leaching and run-off needs further development, and may include, in addition to the P balance, AEIs 11.1 *Soil cover*, AEI 26 *Soil quality* (including soil P status), AEI 7 *Irrigation*, AEI 11.2 *Tillage practice*, AEI 21 *Soil erosion*, and climate, topography, hydrology.

Required data for the P balance:

P inputs

- Manure P applied (**Step IV**).
- P excreted during grazing (**Step V).**
- Mineral P fertilizer application (**Step VI**).

P outputs:

- P removed by harvested crop products (yields), calculated from the yields and P contents of the harvested products per year, cropping patterns (including catch crops and winter crops; soil cover) and grassland area. The AEI 7 *Irrigation* can be used to estimate the yield.

In this step, the data of AEIs 10.1 *Cropping pattern* and 11.1 *Soil cover* are used and those of AIE 26 *Soil quality*, AEI 7 *Irrigation*, AEI 11.2 *Tillage practice*, AEI 21 *Soil erosion*, can be used (see Chapter 7 for further description).

Step X. Nitrate pollution

Data of measured nitrate concentrations in groundwater and surface waters have to be collected at well-defined and described sampling stations, through monitoring programs. For groundwater, one or two samples per years is usually sufficient, for surface waters monthly or quarterly samples have to be taken and analyzed. .

Step XI. Ammonia emissions

The AEI 18 *Ammonia emissions*_is calculated as the sum of the emissions from housing and manure storage (**Step III**), manure application (**Step IV**), grazing (**Step V**), and mineral N fertilizer (**Step VI**).

Step XII. Greenhouse gas emissions

The AEI 19 *Greenhouse gas emissions* is the sum of nitrous oxide, methane and carbon dioxide emissions, all expressed in carbon dioxide equivalents per ha per year. In this report, the non-CO_2 greenhouse gas (N_2O and CH_4) emissions are considered only.

The total direct nitrous oxide emission is calculated as the sum of the emissions from housing and manure storage (**Step III**), manure application (**Step IV**), grazing (**Step V**), and mineral N fertilizer application (**Step VI**).

The total indirect nitrous oxide emission (i.e. the emission related to ammonia emissions and nitrate leaching) have to calculated as:

- Total ammonia emission (**Step XI**) and the emission factor for the indirect nitrous oxide emission from ammonia.
- Total N input to the soil (see **Step VIII**), the leaching fraction (for example, the $FRAC_{leach}$ factor of IPCC), and the emission factor for the indirect nitrous oxide emission from nitrate leached.

Required data:

- The emission factor for the indirect nitrous oxide emission from ammonia,
- The emission factor for the indirect nitrous oxide emission from nitrate,
- The nitrate leaching fraction.

The total methane emission is calculated as the sum of the methane emission from livestock (enteric fermentation; **Step II**) and storage of manure (**Step III**). Notice that wetland rice is also a source of methane, but in EU the area of wetland rice is limited (some regions in Italy, Spain and Bulgaria). Wetland rice is not included in this report, but countries with wetland rice have to include the emission in the calculation of total methane emission.

5.4 Data collection for the other Agri-Environmental Indicators

The AEIs in Figure 8 are related to fertilizer and manure use, emissions of ammonia and greenhouse gases to the atmosphere, and the loss of nitrate and phosphorus to groundwater and surface waters via leaching and run off. Most of these AEIs have a common basis as regards required data and as a result a solid basis for harmonized methods and procedures of data collection and processing.

There are a number of AEIs (from both the first and second set) not covered by this scheme.

There are three AEIs, which are linked with the AEIs in Figure 8, i.e.

- AEI 13. *Specialisation*, related to many AEIs, including fertilizer consumption, cropping patterns, livestock patters, Soil cover, Tillage practice, N balance, and risk of P pollution.
- AEI 12. *Intensification/extensification*, related to fertilizer use, livestock and crop patters, and irrigation.
- AEI 20. *Water abstraction*, related to irrigation

It is recommended to derived these AEIs on the data collected for the AEIs indicated in Figure 8, supplemented with some other data.

From the remaining AEIs, three AEIs are related to use of pesticides:

- AEI 6 Pesticide consumption
- AEI 17 Pesticide risk
- AEI 27.3 Pesticide in water

These AEIs are related in part to the AEIs shown in Figure 8, for example via cropping patterns, as the type and area of crops have a large influence on pesticide use. The AEI *Pesticide risk* has linkages to AEI 17 *Soil cover* and AEI 11.2 *Tillage practice*

There are two AEIs related to energy, i.e.

- AEI 24 Production of renewable energy
- AEI 8 Energy use

These AEIs are also related to some of the AEIs shown in Figure 8. For example, the AEI *Production of renewable energy* is related to AEI 10.1 *Cropping patterns* and that of energy to AEI 5 *Mineral fertilizer consumption*, and AEI 7 *Irrigation.*

Finally, there are AEIs related to land use and the ecological impacts of farming systems, from which part have linkages with each other.

- AEI 1 Agri commitments
- AEI 3 Farmers training
- AEI 4 Area under organic farming
- AEI 2 Agricultural areas under Natura 2000
- AEI 9 Land use changes
- AEI 14 Risk of Farmland abandonment
- AEI 22 Genetic diversity
- AEI 23 High nature farmland
- AEI 28 Landscape
- AEI 25 Farmland birds

It is recommended to use the following approach and procedures for data collection:

1. Firstly, collect the data for the AEIs indicated in Figure 8. This results in:

- AEI 5 Mineral fertilizer consumption,
- AEI 11.3 Manure storage,
- AEI 11.1 Soil cover,
- AEI 10.1 Cropping pattern,
- AEI 7 Irrigation, AEI
- 11.2 Tillage practice,
- AEI 10.2 Livestock pattern.
- AEI 27.1 Nitrate pollution,
- AEI 15 Gross nitrogen balance,
- AEI 18 Ammonia emissions,
- AEI 19 Greenhouse gas emissions (N_2O and CH_4),
- AEI 16 Risk of pollution by phosphorus,
- AEI 26 Soil quality, and
- AEI 21 Soil erosion.

2. Secondly, collect the data for AEIs which are closely related to those of Figure 8:
   - AEI 13. Specialisation,
   - AEI 12. Intensification/extensification,
   - AEI 20. Water abstraction (related to irrigation).

3. Thirdly, collect data related to pesticides, i.e.
   - AEI 6 Pesticide consumption,
   - AEI 17 Pesticide risk, and
   - AEI 27.3 Pesticide in water,

4. Fourth, collect data related to energy, i.e.
   - AEI 24 Production of renewable energy and
   - AEI 8 Energy use;

5. Fifth, collect data related to land use and ecological impacts of farming, i.e.
   - AEI 1 Agri commitments,
   - AEI 3 Farmers training,
   - AEI 4 Area under organic farming,
   - AEI 2 Agricultural areas under Natura 2000,
   - AEI 9 Land use changes,
   - AEI 14 Risk of Farmland abandonment,
   - AEI 22 Genetic diversity,
   - AEI 23 High nature farmland,
   - AEI 28 Landscape, and
   - AEI 25 Farmland birds

In Chapter 7, recommendations for priority data collection are given, with focus on the data needed for the AEIs related to fertilizer and manure use, emissions of ammonia and greenhouse gases to the atmosphere, and the loss of nitrate and phosphorus to groundwater and surface waters via leaching and run off.

6 Priority data collection

6.1 Introduction

In the previous Chapter, a conceptual scheme was presented for collection and calculation of AEIs related nitrogen and phosphorus balances and emissions of ammonia and greenhouse gases. In this Chapter, each AEI (and step in the conceptual scheme) is further unravelled so as to determine the level of detail needed. The data required for the AEIs not covered by these scheme will be discussed shortly at the end of this Chapter. Recommendations for priority data collection are presented in Chapter 8.

6.2 Spatial and temporal scales

For the data collection, the required level of detail on spatial and temporal scale are important. The required level for data collection is largely determined by the required level at which the AEIs have to be reported. Although data collection at a small spatial (field and farm levels) and temporal (seasonal) scales may result in the most accurate estimates, this may be not always feasible, because of the huge demands for human and capital resources. In this chapter, we use the requirements for policy reporting (See Task 2 of DireDate) as starting point..

Besides the spatial and temporal scales, also the method of calculation of AEIs have to be considered. For emissions of ammonia and greenhouse gases, three methodologies can be applied: Tier 1, Tier 2, and Tier 3. Both the UNFCCC-IPCC Guidelines and EEA/EMEP Guidebook use a Tier approach (see report of Task 3 of DireDate). For other AEIs there is no Tier approach.

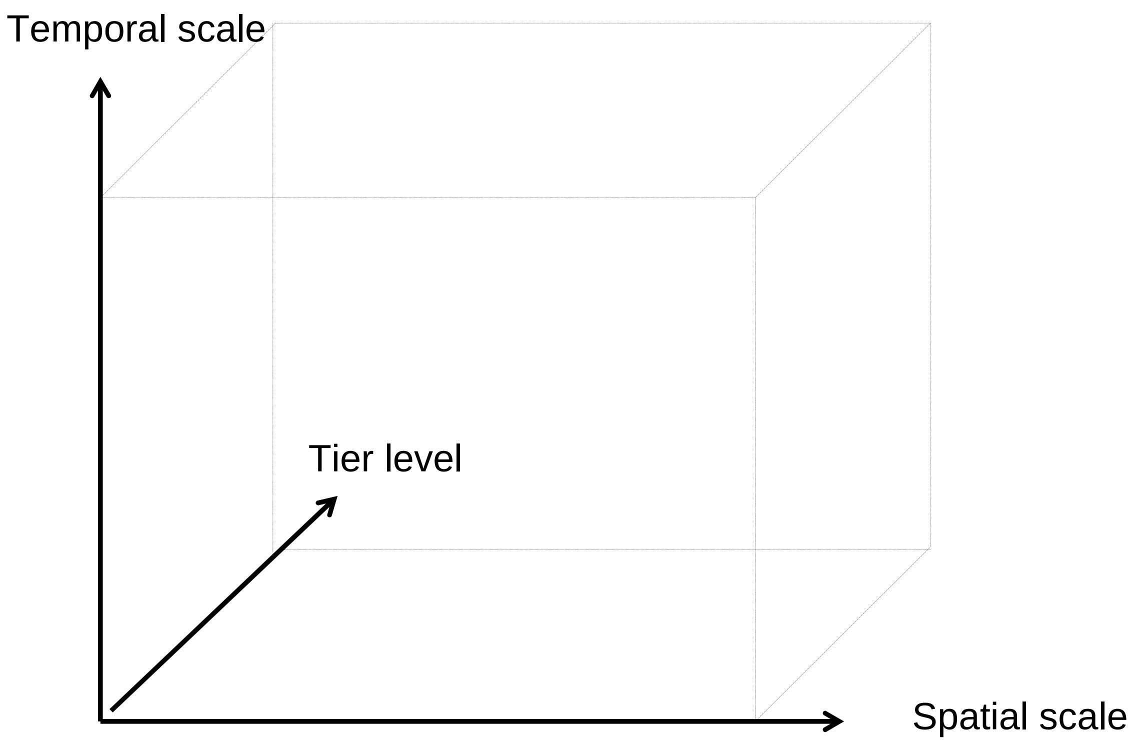
Tier 1 methods are simple methods using standard (default) emission factors. In Tier 2 methods, the emission factors are more differentiated (e.g. based on different types of technology, e.g. application techniques). The Tier 3 methods are country specific methods, often demanding for detailed data. IPCC indicates that countries should use at least Tier 2 methodologies for reporting of emissions from important (‘key‘), and encourage to use of more detailed methodologies than the Tier 2 approach (Tier 3) if possible. This would result in more accurate reporting.

In this Chapter, it is assumed that Tier 2 (for main emission sources) and Tier 1 (for minor sources) approaches will be applied to calculate emissions. It is not possible to give overall recommendations for collection of data for Tier 3 approaches, as the methodologies (and data requirement) may strongly differ between countries.

Thus, three factors have to be considered in collection of data and coefficients: the required spatial scale, the required temporal scale, and the required (Tier) methodology (Figure 9). Although, the Tier level can determine the required level of spatial and temporal scale, this is not always the case. It is possible to calculate the ammonia emissions from a farm (detailed spatial scale) in a specific month (detailed temporal scale) using a simple Tier 1 method. On the other hand, a country specific (Tier 3) method can be used to calculate the total annual ammonia emission of a country.

Figure 9: Schematic presentations of factors determining the level of data collection

i.e. the required temporal scale, the required spatial scale, and the required level of detail of calculation method (i.e. Tier level).



6.3 Required level of detail for Agri-Environmental Indicators related to manure and fertilizer use

In this paragraph, an assessment is made of the data/coefficients needed to calculate the AEIs indicated in Figure 8 at the required spatial and temporal scales, and at the appropriate level of detail.

6.3.1 Total N, P and C excretion by livestock

Step I. Calculate the total annual N and P excretion by the various livestock categories during grazing and in housing systems. The excretion of carbon (C) should be included if this needed for calculating methane emissions from manure storage.

Primary data

The number of livestock for each category is required. The number of livestock have a large effect on the N and P balances, and the calculated ammonia and greenhouse gas emissions. This holds for the major livestock categories (i.e. the categories with highest manure production), such as dairy cattle, beef cattle, sows, fattening pigs, broilers and laying hens. Also other livestock categories, such as sheep and goat, may significantly contribute to the manure production in some countries.

The number of animals per category should be collected at the most feasibly level of detail, i.e. the farm level.

The number of livestock must be representative for the average number during a year. The required unit for each livestock category is the average number of animal heads of live animals per year. This can be estimated using surveys at several times per year or by a survey at one moment in the year. It is important to know the livestock system and, if necessary, ask for additional information to determine if the number of livestock at a certain moment is representative for the whole year. This is especially important for pig and poultry systems with various production cycles (i.e. at which part of the cycle is the number of livestock counted). This estimate can be made by intensive monitoring of the number of livestock, e.g. by calculation at several times in a year, or by correction of number of livestock at a certain moment in a year for changes in number during a year (e.g., livestock places on a farm times mean occupation percentage). For such correction, a thorough knowledge of the management of the livestock production systems is required.

The mean number of animals is used to calculate the manure production. Care have to be take to multiply the mean number of animals by the appropriated N and P excretion per animal (place). Young animals (e.g. number of piglets per sow) have to be known too. For some livestock categories (e.g. sows), the manure production of the young animals (e.g. piglets) is included in that of the adult animal.

It is important to use an uniform methodology and procedure for the estimation of N and P excretion per animal category in the European Union. This is especially the case for livestock categories based on weight. Countries sometimes use different livestock categories, but also within a country there may be differences in the categorization of livestock.

Data collection for animal number are already in place (FSS, livestock statistics, livestock registers). The Livestock survey is a frequent and specialized survey, and provides information about the livestock population in the European Union (EU) at national and regional levels. The survey is carried out at a more detailed level than the Farm structure survey. It is conducted once a year, in December, in all Member States.

The European commission have set up rules on the identification of cattle, pigs, sheep, goat and horses in order to localize and trace the animals for veterinary purposes. This is of crucial importance for the control of infectious diseases. Systems for identification and registration of individual animals include eartags, tattoos and/or passports for individual animals, register of holdings keeping animals, and computerised databases with all holdings and animals at national level. These data bases with livestock registers are a valuable source of number of livestock and distribution of livestock in member states.

Currently, Eurostat reports on number of livestock are based on the obligations for Regulation (EC) No 1165/2008 on livestock and meat statistics (text Box I). Most Member States use statistical surveys to estimate the numbers of cattle, pig, sheep and goat livestock. However, there is no legal obligation to produce livestock statistics for poultry, horses, donkeys, mules or other animals. Part of the equidae are not used for agricultural purpose. For poultry, some estimates are produced on the basis of (i) the number of eggs incubated, (ii) trade in day-old chicks and (iii) chick places. Some countries use the slaughter statistics (Text box II). The legal basis for statistics on eggs and chicks is laid down by Council Regulation (EC) No 1234/2007 establishing a common organisation of agricultural markets and Commission Regulation (EC) No 617/2008 laying down detailed rules as regards marketing standards for eggs for hatching and farmyard poultry chicks. The number is expressed in number of eggs or animals. The number of animals can be used for AEIs.

The periodicity in the current statistics varies according to the species and the country.

- For cattle, two surveys are carried out: one in May/June and one in November/December. All Member States carry out the November/December survey. Bulgaria, Cyprus, Estonia, Finland, Greece, Hungary, Latvia, Lithuania, Luxembourg, Malta, Slovakia and Slovenia, whose bovine populations are below 1 500 000 heads, are not obliged to carry out the May/June survey.

- For pigs, two surveys are carried out: one in May/June and one in November/December. All Member States carry out the November/December survey. Bulgaria, Cyprus, Estonia, Finland, Greece, Ireland, Latvia, Lithuania, Luxembourg, Malta, Portugal, Slovenia, Slovakia and Sweden, whose pig populations are below 3 000 000 heads, may not carry out the May/June survey.
- For sheep and goats, just one survey is carried out annually in November/December. Where country flocks are below 500 000 heads, countries need not carry out a survey.
- For poultry. Monthly for hatchery activity and annually for hatchery structure and incubation capacity.

It is concluded that the Eurostat surveys include detailed livestock categories (Text boxes I and II). However, for AEI and the obligations for environmental policies detailed livestock categories are only useful if the manure, N and P excretion of these categories can be estimated. If not, it is more efficient to aggregate livestock categories. This will be further discussed in the paragraph about N excretion.

The total N, P and C excretion is calculated from the excretion per animal category and the total number of animals per animal category. For estimating emissions, the N, P, and C excretion in housing systems and during grazing have to be calculated separately, on the basis of the time spent in housings and on pastures.

For livestock animals that graze (dairy cattle, beef cattle, sheep, goat, and horses) the number of housing/grazing days or grazing systems have to be derived. In organic farming systems, pigs and poultry may also be kept outdoors for part of the year, but the percentage of animals in organic farming systems is still relatively low (~5%). In some statistical surveys, information about grazing is gathered. For example, in the Netherlands three systems of grazing are considered: day and night grazing during the growing season, permanent housing, and restricted grazing. This information has to be translated in N and P excretion in housing systems and N and P excretion during grazing, which demands for detailed information about grazing and detailed calculation methods and coefficients.

There may be clear differences in grazing systems between regions, especially in countries with large regional differences in dairy farming systems. In such countries, grazing systems have to be derived at least at regional level, i.e. Nuts II level. It is recommended to collect data about grazing system of cattle (i.e. the major category) at farm level.

Recommendations:

- The number of livestock should be collected at farm level and give an estimate of the average number of animal heads of live animals per year per livestock category.
- The unit is live animal per animal category per year.
- Detailed collection of the number of livestock categories for AEIs is only useful if the N and P excretion of these categories can be estimated. If not, it is more efficient to aggregate livestock categories.
- An accurate estimate of the major animal categories (i.e. with highest manure production) has the highest priority, which are generally dairy cattle, beef cattle, sows, fattening pigs, broilers and laying hens. However, in certain member states also other livestock categories significantly contribute to the manure production in a country, such as sheep and goat.
- The current data collection surveys estimate cattle, pig, sheep and goat livestock numbers. However, there is no legal obligation to produce livestock statistics for poultry, horses, donkeys, mules or other animals. The number of poultry can be estimated from the statistics on eggs and chicks. The contribution of horses, donkeys, mules or other animals in the total manure production is generally

small. Collection of number of these numbers of livestock does not have a high priority.

- It is recommended to collect data about grazing system of cattle (i.e. the major category) at farm level.
- The data about grazing systems or time need to be translated in N and P excretion in housing and during grazing. Methodology and coefficients are needed for this.

Coefficients

For the calculation of the manure production, the N, P, and C excretion for each animal category. The N, P, and C excretion depend on the type of livestock and the diet. There are clear differences between farms in N and P excretion, because of different diets. However, there are no methods available to estimate the excretion on farm level for all livestock categories.

Basically, there are two methods to estimate N excretion:

- The excretion is calculated as the difference between the N intake by the animal and the retention of N in marketed products (milk, meat, eggs, wool).
- The excretion is calculated from the volume of excretion (volume of manure) and the N content of the excretion.

The methods are similar for P. Both methods have difficulties and uncertainties. Generally, the first method is preferred, but care should be taken that the estimates are based on figures that represent actual farms (and not experimental or model farms).

In the Netherlands, dairy farmers can use a tool to calculate the farm specific N and P excretion of their cattle (BEX). The following information is used: number of livestock for each category, milk production, weight of cattle, energy requirements young cattle, and grazing time. The calculation method is based on a scientific report[86]. Such a method may be further developed and applied in EU-27. The methodologies to calculate the excretion of other livestock categories on farm level are available, but need detailed data about feed composition and animal production. The calculation of the N excretion on the farm scale can be considered as a development for the long-term, but it not feasible on the short-term. For the short-term, estimates using default figures have to be used.

It is well-known that the N excretion of dairy cattle is strongly affected by the diet and N management. There is a clear relation between the N excretion and the milk production. Therefore, it is recommended to use region-specific (i.e. Nuts II level) excretion factors in countries with large regional differences in N excretion. For example, the average annual milk production per cow in France ranges from less than 5000 (e.g. in Languedoc-Roussillon) to 7700 litter (Île de France). This indicates that the N excretion ranges from about 70 to about 120 kg N per cow per year. This shows that there is a substantial regional difference in N excretion. Also in other countries, there may be large differences between regions in N excretion.

For countries with small regional differences in milk production of dairy cattle and for all other categories, country-specific N excretion per animal category are recommended. The regional differences in N and P excretion of the other livestock categories are generally much smaller than those of dairy cattle, because differences in feeding rations are relatively small for these categories.

There are several sources for N and P excretion rates, including the IPCC guidelines, the national reports for the Nitrates Directive, the data-base of the GAINS model and OECD. Differences between these data bases are

[86] Tamminga, S., F. Aarts, A. Bannink, O. Oenema & G.J. Monteny, 2004. Actualisering van geschatte N en P excreties door rundvee. Reeks Milieu en Landelijk gebied 25.

mainly due to different methods used and/or institutions/person who derive the estimates. No general recommendation can be given about the source to be used.

Member states of the European Union have to report N excretion values in their Action Programmes for the Nitrates Directive (i.e. the N excretion in Nitrate Vulnerable Zones). The approaches to calculate the N excretion and the livestock categories considered largely differ between the member states. Many countries use a feed balance method to calculate N excretion for a large number of animal categories, but some countries use default estimates of N excretion. Countries that use a detailed approach to calculate N excretions are for example France and the Netherlands. The underpinning of France is presented in various CORPEN reports[87].

The advantage of the use of Action Programmes of the Nitrate Directive to estimate the N excretion is that countries are obliged to report them. However, the N excretion rates presented in the reports for the Nitrates Directive strongly differ between member states, which is partly due to differences in methodology. Some countries use relatively rough estimates for N excretion for a few major categories, whereas other countries calculate N excretion for a large number of categories, such as France[88] and the Netherlands. These calculations are based on common input and output relations, as also described in a methodology report for the European Commission of Ketelaars and van der Meer (2000)[89].

Generally, most studies focus and N and P excretion, and methodologies to estimate N and P excretion are available. However, the estimate of C excretion and especially the volatile solids (needed to calculate methane emission) is less well developed. The IPCC presents a methodology to calculate volatile solid excretion (see Task 3).

For countries that use a method based on Total Ammoniacal N (TAN; ammonium-N + N compounds readily broken down to ammonium) to calculate ammonia emission, the TAN excretion also have to be included. This can be done using standard values for TAN[90] in the N excretion for different categories or a calculated TAN excretion, based on the composition of feed[91].

If there are no data collected of housing/grazing days, they have to be estimated using expert judgement of experts knowing the farming system. A possible source is the RAINS/GAINS data base. For each member state, the N excretion in housing and during grazing is estimated, on basis of consultations with experts of member states.

Eurostat intend to analyse the results of the Survey on Agricultural Production Methods (SAPM) to find out more about the characteristics of the grazing livestock production systems, in particular housing vs. grazing and pasture vs. maize silage vs. concentrates. SAPM is a sample survey related to the FSS but recording different characteristics. The SAPM will not answer these directly, but could potentially be estimated through

[87] CORPEN (1996) Estimation des rejets d'azote par les élevages avicoles.

CORPEN (1999) Estimation des flux d'azote, de phosphore et de potassium associés aux vaches laitières et à leur système fourrager.

CORPEN (2001) Estimation des flux d'azote, de phosphore et de potassium associés aux bovins allaitants et aux bovins en croissance et à l'engrais, issus des troupeaux allaitants et laitiers et à leur système fourrager.

CORPEN (2003) Estimation des rejets d'azote, de phosphore, de potassium, de cuivre et de zinc des porcs - Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections produites (nouveau document 2003)

[88] CORPEN, 2003. Estimation des rejets d'azote, de phosphore, de potassium, de cuivre et de zinc des porcs - Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections produites. Ministère de l'Ecologie et du Développement Durable, Paris. http://www.ecologie.gouv.fr/IMG/CORPEN/Rapport_Corpen_Porc_Juin2003.pdf

[89] Ketelaars, J.J.M.H. and van der Meer, H.G. (2000). Establishment of criteria for the assessment of the nitrogen content of animal manures. Final report to ERM, carried out on behalf of DG XI of the European Commission. AB-DLO, Wageningen, ERM London, 68 p.

[90] Reidy B, Dämmgen, U. Döhler, H. Eurich-Menden, B. Evert F.K. van, Hutchings N.J., Luesink. H.H., Menzi. H., Misselbrook T.H., Monteny G.J., and Webb. J. (2008a) Comparison of models used for the calculation of national ammonia emission inventories in Europe: liquid manure systems. Atmospheric Environment 42, 3452-3464.

[91] Velthof, G.L., C. van Bruggen, C.M. Groenestein, B.J. de Haan, M.W. Hoogeveen and J.F.M. Huijsmans A model for inventory of ammonia emissions from agriculture in the Netherlands. In preparation

the forage area per holding.

The grazing/housing time has to be translated into N excretion in housing and grazing. A simple method is to estimate the time in housing and the time of grazing and divide the total annual N excretion over housing and grazing. Notice that also in permanent grazing systems, part of the N may be excreted in housing, e.g. during milking). However, the composition of the feed differs in systems with grazing and housing (i.e. richer in protein during the grazing time). Therefore, the daily N excretion is generally higher during the grazing season than during the housing period. If this information is available, it can be used to derive a better estimate of the N and P excretion in housing and during grazing. For example, in the Netherlands the seasonal effect on N excretion of dairy cattle is used to estimate the N excretion in housing and during grazing.

An accurate estimate of the N excretion in housing and during grazing is important, because the fate of N excreted in housing (i.e. losses in housing, manure storage, and manure application) differs from that excreted during grazing (i.e. N losses from urine patches). For P, this effect is smaller. The P excreted during grazing is more heterogeneously distributed in the field than P applied as manure, which affects crop yield and P losses. However, the current methods to calculate balances and emissions do not yet account for these effects.

Recommendations:

- Use region specific N and P excretion rates for dairy cattle in countries, where large regional differences in milk production occur. For countries with small regional differences in milk production and for all other livestock categories, N and P excretion have to be estimated on a country level
- Develop an uniform approach to calculate N and P excretion in the EU-27 countries. The methodology to calculate N and P excretion, using input-output balances and several data sources, are available. It is recommended to install a Task force to develop a uniform methodology to estimate N and P excretion in EU-27.
- Some countries have systems in place to calculate N and P excretion by livestock, based on country specific feed composition and livestock production (e.g. used in Action Programmes for the Nitrates Directive). On the short term (i.e. until an European wide approach has been developed), it is recommended that these countries use the calculated N and P excretion rates for the AEIs. Other countries are recommended to develop such a calculation method.
- The N and P excretion must be expressed in kg N or kg P (or P_2O_5) per live animal per year.
- The focus on improvement of N and P excretion figures must focus on the major categories such as dairy cattle, beef cattle, sows, fattening pigs, broilers and laying hens, as these categories have the largest effect on manure production and related emissions.
- For countries that use a method based on TAN-based method to calculate ammonia emissions, the TAN excretion has to be estimated. This can be done using standard values for TAN or by calculated from the composition of feed.
- For calculation of the C excretion, the IPCC methodology can be used.
- At the short term, it is recommended to estimate the time in housing and the time of grazing and divide the total annual N excretion over housing and grazing using the housing and grazing days.
- At the long term, it is recommended to estimate the C, N and P excretion during housing and grazing based on possible seasonal differences in excretion (e.g. higher N excretion during the grazing season, because higher protein content of the feed).

TEXT BOX I. LIVESTOCK CATEGORIES USED IN EUROSTAT SURVEYS FOR CATTLE, PIG, SHEEP AND GOAT

For cattle:

A Bovine animals aged not over than 1 year:
- a) calves and young cattle for slaughter;
- b) other:
  - ba male;
  - bb female;

B Bovine animals aged over 1 year but under 2 years (except females that calved):
- a) male;
- b) female (heifers; animals that have not yet calved);
  - ba animals for slaughter;
  - bb other;

C Bovine animals of 2 years and over:
- a) male;
- b) female:
- ba heifers;
  - 1. heifers for slaughter;
  - 2. other;
- bb cows (include bovines under 2 years old that have calved):
  - 1. dairy cows;
  - 2. other;

D Buffaloes:
- a) female breeding buffaloes;
- b) other buffaloes.

For pigs:

A Piglets with a live weight of less than 20 kg;
B Pigs with a live weight of 20 kg or more but less than 50 kg;
C Fattening pigs, including cull boars and cull sows with a live weight:
- a) of 50 kg or more but less than 80 kg;
- b) of 80 kg or more but less than 110 kg;
- c) of 110 kg or more;

D Breeding pigs with a live weight of 50 kg and higher;
- a) boars;
- b) covered sows, of which:
- b1 sows covered for the first time;
- c) other sows, of which:

c1 gilts not yet covered;

For sheep and goats:

Sheep
A ewes and ewe lambs put to the ram:
- a) milk ewes and milk ewe lambs put to the ram;
- b) other ewes and ewe lambs put to the ram;

B other sheep.

Goats
A goats which have already kidded and goats mated:
- a) goats which have already kidded;
- b) goats mated for the first time;

B other goats.

TEXT BOX II. DEFINITIONS OF EGGS, CHICKS AND POULTRY AND THEIR CATEGORIES AND USES COVERED IN THE STATISTICS

1. "**Eggs for hatching**" means poultry eggs falling within subheading 0407 00 11 and 0407 00 19 of the Combined Nomenclature intended for the production of chicks, classified according to species, category and type and identified in accordance with Regulation (EC) No 617/2008, produced in the Community or imported from third countries.
2. **"Chicks**" means live farmyard poultry the weight of which does not exceed 185 grammes, either produced in the Community or imported from third countries and falling within subheadings 0105 11 and 0105 19 of the Combined Nomenclature, of the following categories:

   (a) Utility chicks: chicks of one of the following types:

   (i) table type chicks: chicks intended to be fattened and slaughtered before reaching sexual maturity;

   (ii) laying chicks: chicks intended to be raised with a view to the production of eggs for consumption;

   (iii) dual-purpose chicks: chicks intended either for laying or for the table.

   (b) Parent stock chicks: chicks intended for the production of utility chicks.

   (c) Grandparent stock chicks: chicks intended for the production of parent stock chicks.

3. "**Establishment**" means the establishment or part of an establishment for each of the following sectors of activity:

   (a) Pedigree breeding establishment: an establishment for the production of eggs for hatching intended for the production of grandparent stock, parent stock or utility chicks.

   (b) Breeding establishment: an establishment for the production of eggs for hatching intended for the production of utility chicks.

   (c) Hatchery: an establishment for incubating eggs, hatching and supplying chicks.

4. "**Capacity"** means the maximum number of eggs for hatching which may be placed simultaneously in incubators excluding hatchers.

Poultry:

5. COCKS, HENS, CHICKENS (Gallus gallus)

6. TURKEYS (Meleagris spp.)

7. DUCKS (Anas spp., Cairina moschata)

8. GEESE (Anser anser domesticus)

9. GUINEA FOWL (Numida meleagris domesticus)

6.3.2 N and P imported and exported as manure

Step II. Calculate the amounts of N and P imported and exported as manure.

Primary data

The export/import of manure is important for regions with high livestock density and specialized landless farms. Generally, livestock farms will apply the produced manure on their own land or land in the neighbourhood as transport of manure is costly.

The calculation unit for N and P balances, ammonia emission, and greenhouse emission is the national or regional scale. There are no obligations for calculations on the farm scale. Therefore, the export/import of manure have to be considered on region scale (i.e. transport between regions) or national scale (i.e. transport between countries).

The export/import of manure is probably only an issue in region with intensive livestock production, such as Flanders, Netherlands, the Po area in Italy, Brittany in France.

The total amount of manure N and P transported between regions and between countries have to be collected. In some member states (e.g. Belgium-Flanders and the Netherlands) transport of manure is registered. This information can be used to estimate import and export.

Coefficients

The transport of manure is mostly based on volumes. The amount of N and P transported have to be estimated using average N and P contents of the manure. In most member states, composition of manures are indicated in action programmes of the Nitrates Directive and/or fertilizer recommendations.

If there are no primary data collected about manure transport, the transport of manure has to be estimated by expert judgement or calculated using application standards (i.e. the manure application standard of the Nitrates Directive) and/fertilizer recommendations.

Recommendations

- The export/import of manure have to be considered on region scale (i.e. transport between regions) or national scale (i.e. transport between countries).
- The transport of manure is mostly based on volumes. The amount of N and P transported have to be estimated using average N and P contents of the manure. In most member states, composition of manures are indicated in action programmes of the Nitrates Directive and/or fertilizer recommendations. These mean N and P contents should have a firm and scientifically sound underpinning.

If there are no primary data collected about manure transport, the transport of manure has to be estimated by expert judgement or calculated using application standards. Again, these mean N and P contents should have a firm and scientifically sound underpinning.

6.3.3 Gaseous emissions from livestock, housing and manure storage

Step III. Calculate the gaseous emissions from livestock (IIIA) and housing and manure storage (IIIB): N_2O, NH_3, and CH_4. In order to calculate the amount of N that is transported from manure storage to the field, also the N_2 emission has to be calculated. The emission is dependent of type manure storage.

Step III A. Calculate the CH_4 emission from enteric fermentation.

The CH_4 emission from enteric fermentation is calculated from the number of livestock per category and a CH_4 emission factor.

Primary data

The required data are already collected in Step I of the scheme. No additional data are required.

Coefficients

The IPCC guidelines describes different methodologies (Tier 1, 2, and 3) to calculate CH_4 emission from enteric fermentation. The need for primary data and coefficients is dependent on the chosen Tier approach. The Tier 1 method is likely to be suitable for most animal species in countries where enteric fermentation is not a key source category, or where enhanced characterization data are not available. When approximate enteric emissions are derived by extrapolation from main livestock categories they should be considered to be a Tier 1 method. Table 12 shows the suggested methodology of IPPC.

For a Tier 1 approach, no additional primary data are needed for most livestock categories. The CH_4 emission is calculated from the number of livestock and the IPCC emission factors for enteric fermentation (Table 10.10 and 10.11 in IPCC Guidelines 2006). For cattle, there are specific emission factors for Western and Central Europe (dependent of milk production).

For a Tier 2 approach, country specific information on livestock populations and manure management practices are needed. The minimum representative types for Tier 2 methods for cattle are mature dairy cattle, mature non-dairy cattle and young cattle. Similar categories can be used for buffalo. Swine can be divided into sows, boars and growing animals. These can be further divided into sub-categories if data are available

Table 12: Suggested emission factors for enteric fermentation
(Table 10.9 from IPCC 2006 guidelines)

TABLE 10.9
SUGGESTED EMISSIONS INVENTORY METHODS FOR ENTERIC FERMENTATION

Livestock	Suggested emissions inventory methods
Dairy Cow	Tier 2[a]/Tier 3
Other Cattle	Tier 2[a]/Tier 3
Buffalo	Tier 1/Tier 2
Sheep	Tier 1/Tier 2
Goats	Tier 1
Camels	Tier 1
Horses	Tier 1
Mules and Asses	Tier 1
Swine	Tier 1
Poultry	Not developed
Other (e.g., Llamas, Alpacas, Deer)	Tier 1

[a] The Tier 2 method is recommended for countries with large livestock populations. Implementing the Tier 2 method for additional livestock subgroups may be desirable when the category emissions are a large portion of total methane emissions for the country.

The enteric fermentation emission factors in Tier 2 approach for each representative type of livestock are estimated based on the average daily feed intake and methane conversion rate. The IPCC Guidelines 2006 describe in detail the method to derive the CH_4 emission factor for enteric fermentation, which demands for the following data

- weight (kg);
- average weight gain per day (kg);
- feeding situation: confined, grazing, pasture conditions;
- milk production per day (kg/day) and fat content (%);
- average amount of work performed per day (hours day^{-1});
- mean winter temperature (ºC):
- percentage of females that give birth in a year;
- wool growth;
- number of offspring; and
- feed digestibility (%).

Current Tier 1 and Tier 2 enteric methane emissions factors and estimation procedures are driven by first estimating daily and annual gross energy consumption by individual animals within an inventory class which are then multiplied by an estimate of CH_4 loss per unit of feed. There is considerable room for improvement in Tier 2 prediction of both feed intake, such as breed or genotype variation in maintenance requirement, heat and cold stress effects on intake and maintenance requirements, and depression in digestibility with increasing levels of consumption, or diet composition limits to diet intake. These type of factors can be included in a Tier 3 approach to calculate CH_4 emission.

Recommendations:

- The CH_4 emission from enteric fermentation is calculated from the number of livestock per category and a CH_4 emission factor.
- The important livestock categories are ruminants, and especially dairy cattle and beef cattle. Other livestock categories that may significantly contribute to national CH_4 emissions in certain countries are sheep.
- For CH_4 emission factors, it is recommended to follow IPCC guidelines (minimum requirement), i.e. a Tier 2 method for dairy cattle and other cattle, and Tier 1 for the other categories. The CH_4 emission factor should be derived on a national level.
- The Tier 1 CH_4 emission factors are presented in Tables 10.10 and 10.11 in IPCC Guidelines 2006.
- The Tier 2 CH_4 emission factors for dairy and other cattle have to be calculated using the methodology described by IPCC. This methodology demands for detailed data, including
  - weight (kg);
  - average weight gain per day (kg);
  - feeding situation: confined, grazing, pasture conditions;
  - milk production per day (kg/day) and fat content (%);
  - average amount of work performed per day (hours day^{-1});
  - mean winter temperature (ºC):
  - percentage of females that give birth in a year;
  - wool growth;
  - number of offspring; and
  - feed digestibility (%).

Step III B. Calculate the N_2O, NH_3, and CH_4 emissions from housing and manure storage per year.

Calculate the gaseous emissions from housing and manure storage: N_2O, NH_3, and CH_4. In order to calculate the amount of N that is transported from manure storage to the field, also the N_2 emission has to be calculated. The emission is dependent of type manure storage.

Primary data

Data needed in addition to the data collected in the previous steps are the type housing and the type of manure storage.

The type of data about housing and manure systems to be collected strongly depends on the methodologies that countries use to estimate the NH_3 and greenhouse gas emissions. For Tier 1 less detailed information is required than for Tier 2. The IPCC guidelines provide estimates for emissions factors of greenhouse gas emissions for several manure management systems: (i) anaerobic lagoon, (ii) liquid system, (iii) daily spread, (iv) solid storage and drylot, (v) pasture range and paddock, (vi) used fuel, and (vii) other systems.

The IPCC also indicates that the best means of obtaining manure management system distribution data is to consult regularly published national statistics. If such statistics are unavailable, the preferred alternative is to conduct an independent survey of manure management system usage. If the resources are not available to conduct a survey, experts should be consulted to obtain an opinion of the system distribution. If country-specific manure management system usage data are not available, default values should be used. The IPCC presents default values for dairy cows, other cattle, buffalo, swine, and poultry.

In Task 3 it was concluded that the following data about housing systems and manure storage systems are needed to enable the application of a Tier 2 or Tier 3 methodology for the estimation of CH_4, N_2O and NH_3 emissions:

- Yard flooring – no leachate capture
- Yard flooring – leachate capture
- Amount of straw added as bedding
- Direct spreading of manure
- Housing: fully-slatted floor
- Housing: partially slatted floor
- Housing: tied
- Housing: loose
- Housing: mechanical ventilation
- Housing: scrubbers or biofilters
- Manure separation
- Manure to anaerobic digester (AD)
- Supplement added to AD: Food waste
- Supplement added to AD: Crop residues
- Supplement added to AD: Whole crops
- Slurry stored in open tanks
- Slurry stored in covered tanks
- Slurry stored in lagoons
- Slurry stored in underfloor pits
- Manure stored in manure heaps
- Manure composted
- Manure incinerated

It must be noted that these data requirements reflect the ideal situation, and that these data also demands for detailed emission factors (see coefficients). If the methodology and coefficients are not available, less detailed data are required.

The GAINS model uses a Tier 1 approach, in which for pigs and cattle liquid and solid manure management systems are considered and for the other livestock categories one (average) system. For member states that do not have sufficient data to use Tier 2 or Tier 3, it is recommended to use a Tier 1 approach using the manure management systems indicated by IPPC 2006 Guidelines or the GAINS model.

Coefficients

Emission factors are needed for type of housing, manure storage, and type of manure.

As a minimum requirement (Tier 1), it is recommended to use default emission factors for NH_3, N_2O, NOx, and CH_4 presented in IPCC Guidelines and the EMEP/EEA Guidebook. Both sources contain detailed tables with emission factors which are intended to be reasonable estimates for the specified geographic area. These default values often disguise a wide geographic variation in actual values, either due to variations in climate or to regional variations in agricultural practices. In addition, the default values presented in the various guidance documents generally relate to situations where no abatement measures have been implemented. For using Tier 2 and Tier 3, detailed, country specific, emission factors can be used. Member states can use country-specific or region-specific coefficients if these coefficients can be scientifically underpinned.

In the Scheme A of Figure 7, the N flows is calculated from N excreted in housing to N applied to soils. This means that all N losses have to be considered. Denitrification is the microbial reduction of nitrate to gaseous N (N_2O, NOx and N_2). There are no obligations to estimate total denitrification losses. However, for the calculation of the manure N applied to soils, also the N_2 and NOx losses in housing systems have to be considered. In systems with solid manure, total denitrification losses are high (20-40% of the N excreted) and much higher than the losses in slurry systems. Therefore, the total denitrification loss in housing and manure storage systems have to be considered to estimate the manure N application to soils.

Default emission factors for NOx and N_2 are presented in the EEA/EMEP guidebook for slurry and solid manure, i.e. for slurry systems: 0.01% NO, and 0.3% N_2 and for solid systems 1% NO, and 30% N_2 of the ammonium-N (TAN) excreted. Some countries use country-specific estimates, such as France and the Netherlands.

For countries that use a TAN-based methodology to calculate ammonia emissions (Task 3 and EEA/EMEP Guidebook), the mineralization and immobilization of N during the storage of manure have to be calculated. It is recommended to follow EEA/EMEP Guidebook.

Recommendations

- For member states that apply a Tier 2 or Tier 3 methodology for the estimation of CH_4, N_2O and NH_3 emissions, detailed information about housing and manure systems is needed. The required data are dependent on the used methodology and coefficient. In the ideal situation, the data includes information about type of floor (capture/no capture of leachate), amount of straw added as bedding, direct spreading of manure, housing (fully-slatted floor, partially slatted floor, tied, loose, mechanical ventilation, scrubbers or biofilters), manure separation, manure to anaerobic digester (AD), supplements added to AD (food waste, crop residues, whole crops), slurry storage (open tanks, covered tanks, lagoons, underfloor pits), manure stored in manure heaps, manure composted, and manure incinerated.
- For member states that do not have sufficient data to use Tier 2 or Tier 3, it is recommended to use a Tier 1 approach using the manure management systems indicated by IPPC 2006 Guidelines or the GAINS model.
- The IPCC guidelines provide estimates for emissions factors of greenhouse gas emissions for several manure management systems: (i) anaerobic lagoon, (ii) liquid system, (iii) daily spread, (iv) solid

storage and dry lot, (v) pasture range and paddock, (vi) used fuel, and (vii) other systems.

- The GAINS model uses a Tier 1 approach, in which for pigs and cattle liquid and solid manure management systems are considered and for the other livestock categories one (average) systems.
- The primary data on housing systems and manure storage systems should be collected at the farm level.
- The coefficients to calculate the amount of manure stored and the emissions of NH_3, N_2O, N_2, and CH_4 have to be determined (minimum level) at international level (e.g. IPCC or EEA/EMEP Guidelines). Member states can use country-specific or region-specific coefficients if these coefficients can be scientifically underpinned.
- For the calculation of the manure N applied to soils, also the N_2 and NOx losses in housing systems have to be considered. It is recommended to use the default emission factors for NOx and N_2 presented in the EEA/EMEP guidebook for slurry and solid manure or country-specific values.
- For countries that use a TAN-based methodology to calculate ammonia emissions (Task 3 and EEA/EMEP Guidebook), the mineralization and immobilization of N during the storage of manure have to be calculated. It is recommended to follow EEA/EMEP Guidebook.

6.3.4 Manure N application and associated emissions of NH_3 and N_2O.

Step IV. Calculate the amount of manure N applied to the soil, and the associated emissions of NH_3 and N_2O.

Primary data

The total amount of manure applied to the soil (expressed in N and P) is calculated from the previous steps:

- Total N and P excretion of livestock
- The N and P excreted in housing
- Correction for gaseous emissions (eventually for N mineralization in manure storage, if a TAN-based approach is used)
- Correction for export and import of manure

This calculation results in total amounts of manure for each livestock category and the type of manure (slurry or solid).

To calculate the ammonia and nitrous oxide emissions related to manure application and to calculate the N and P balance on crop or regional level, additional data are needed about the application technique and the crop to which the manure is applied. For detailed Tier 3 methodologies, additional data may be required (e.g. soil type).

In Task 3, it was recommended to collect data about the following manure application techniques in Tier 2 or Tier 3 methods:

- Broadcast – no incorporation
- Broadcast – incorporation <2hrs
- Broadcast – incorporation <1 day
- Bandspread
- Deep injection
- Shallow injection

In a Tier 1 method, it is recommended to distinguish between broadcast-no incorporation and reduced ammonia application technique (i.e. the other techniques).

For the distribution of manure on crops, it is recommended to use a modelling approach and expert judgement, as indicated in the paragraph on mineral N fertilizer use (paragraph 7.2.6). These estimates can be checked with small surveys on farms, which can be combined with survey on N and P mineral fertilizers.

Coefficients

For the calculation of ammonia and nitrous oxide emissions, emission factors for ammonia and nitrous oxide have to be used (in % of the N applied). Default (Tier 1 or Tier 2) emission factors can be used, as presented in EEA/EMEP Guidebook and IPCC Guidelines. It depends on the chosen methodology to calculate the emissions, at what detail level emission factors have to be derived. Some countries have developed country specific approaches to calculate ammonia emissions and emission factors are available[92].

Recommendations:

- Use the default emission factor of ammonia and nitrous oxide (in % of the N applied) presented in EEA/EMEP Guidebook and IPCC Guidelines.
- If data are available, derive country specific emission factors for ammonia and nitrous, e.g. dependent on factors as mineral N fertilizer type, manure N application technique, crop and soil type.

6.3.5 N and P excreted during grazing, and the associated emissions of NH_3 and N_2O.

Step V. Calculate the N and P excreted during grazing, and the associated emissions of NH_3 and N_2O.

Primary data

No additional data are needed. The N and P excreted during grazing is calculated from the total N and P excretion and the housing/grazing days. The N and P is deposited on grassland.

Coefficients

For the calculation of ammonia and nitrous oxide emissions, emission factors for ammonia and nitrous oxide have to be used (in % of the N applied). The EEA/EMEP Guidebook and IPCC Guidelines can be used for default emission factors. Countries may use country specific emission factors. For example, the Netherlands use an approach in which the ammonia emission factor for grazing is dependent of the N content of the feed

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[92] Gac A., F. Béline, T. Bioteau, and K. Maguet (2007) A French inventory of gaseous emissions (CH4. N2O. NH3) from livestock manure management using a mass-flow approach. Livestock Science 112 (2007) 252–260.

yde, B.P., O.T. Carton, P. O'toole, and T.H. Misselbrook (2003) A new inventory of ammonia emissions from Irish agriculture. Atmospheric Environment 37, 55–62.

Hutchings N.J., S.G Sommer. J.M Andersen and W.A.H. Asman (2001). A detailed ammonia emission inventory for Denmark. Atmospheric Environment 35, 1959-1968.

Reidy B, Dämmgen, U. Döhler, H. Eurich-Menden, B. Evert F.K. van, Hutchings N.J., Luesink. H.H., Menzi. H., Misselbrook T.H., Monteny G.J., and Webb. J. (2008a) Comparison of models used for the calculation of national ammonia emission inventories in Europe: liquid manure systems. Atmospheric Environment 42, 3452-3464.

Reidy B., B. Rhim and H. Menzi (2008b) A new Swiss inventory of ammonia emissions from agriculture based on a survey on farm and manure management and farm-specific model calculations. Atmospheric Environment 42, 3266-3276.

Reidy B., Webb J., Misselbrook T.H., Menzi H., Luesink H.H., Hutchings N.J., Eurich-Menden B., Dohler H., and Dammgen U. (2009) Comparison of models used for national agricultural ammonia emission inventories in Europe: Litter-based manure systems. Atmospheric Environment 43, 1632 - 1640.

Velthof, G.L., C. van Bruggen, C.M. Groenestein, B.J. de Haan, M.W. Hoogeveen and J.F.M. Huijsmans A model for inventory of ammonia emissions from agriculture in the Netherlands. In preparation

Webb J., and T.H. Misselbrook (2004) A mass-flow model of ammonia emissions from UK livestock production. Atmospheric environment 38, 2163-2176.

during the grazing season (which depends on the N application to the grazed swards and supplemental feeding).

Recommendations

- Use the default emission factor of ammonia and nitrous oxide for N excreted during grazing (in % of the N applied) presented in EEA/EMEP Guidebook and IPCC Guidelines.
- If data are available, derive country specific emission factors for ammonia and nitrous, e.g. the dependent of the N content of the feed.

6.3.6 N and P fertilizer application and associated emissions of NH_3 and N_2O

Step VI. Calculate the amount of N and P applied as N and P fertilizer, and the emissions of NH_3 and N_2O associated with N fertilizer use

Primary data

The total N fertilizer consumption is needed on regional scale, as the calculations for the balances and emissions are based on regional and national scale. For the Nitrates Directive the amount of N fertilizer used in nitrate vulnerable zones is needed.

For the N balance, the total applied N is required and the type of N fertilizer is not required. However, the ammonia emission factor is dependent on the type of N fertilizer, so that information of the type of fertilizer is needed. Fertilizer with high risk are urea, urea-containing fertilizers, and ammonium fertilizers. There is not risk of ammonia emission after application of nitrate containing fertilizers. In Table 13 the emission factors for mineral N fertilizers are presented (Tier 2 method EEA/EMEP Guidebook).

Table 13: Ammonia emission factors for mineral N fertilizers (Table 3-2 EEA/EMEP Guidebook)

Table 3-2 Emission factors for total NH_3 emissions from soils due to N fertiliser volatilization and foliar emissions for various climatological regions with adjustments for emissions on soils of pH > 7.0. Values are kg NH_3 volatilized per kg fertiliser-N applied and the mean spring temperature t_s (in °C). Derived from van der Weerden and Jarvis (1997) and expert judgement

Fertiliser type	EF_i	Multiplier c
Ammonium sulphate	$= 0.0107 + 0.0006\ t_s$	[1] 10
Ammonium nitrate	$= 0.0080 + 0.0001\ t_s$	1
Calcium ammonium nitrate	$= 0.0080 + 0.0001\ t_s$	1
Anhydrous ammonia	$= 0.0127 + 0.0012\ t_s$	4
Urea	$= 0.1067 + 0.0035\ t_s$	1
Nitrogen solutions	$= 0.0481 + 0.0025\ t_s$	1
Ammonium phosphates	$= 0.0107 + 0.0006\ t_s$	[1] 10
Other NK and NPK	$= 0.0080 + 0.0001\ t_s$	1

Note
[1] The multipliers are used when these fertilisers are applied to soils with pH > 7.0 (Harrison and Webb, 2001).

It is recommended to collect the use of the following types of N fertilizers:

- Ammonium sulphate
- Ammonium nitrate

- Calcium ammonium nitrate
- Anhydrous ammonia
- Ammonium phosphate
- Urea
- Urea-ammonium nitrate solution (UAN)
- Other

Emission factors for N_2O are based on N applied as mineral fertilizer. The default IPCC method does not distinguish between N fertilizer types. However, countries may use country-specific emission factors, which may demand for data of the use of specific mineral N fertilizers.

For national estimates of ammonia and nitrous oxide emissions, the mineral N fertilizer use on the national scale is sufficient. The national mineral N fertilizer use is multiplied with the emission factor for ammonia and nitrous oxide. For ammonia, the national use ammonium nitrate, calcium ammonium nitrate, anhydrous ammonia, ammonium phosphate, urea, urea-ammonium nitrate solution (UAN), and other N fertilizers is needed and for nitrous oxide the total mineral N fertilizer use. Data from fertilizer producers and retailers (e.g. via EFMA) may be used, but may need a correction to translate fertilizer production in fertilizer consumption. EFMA provides statistics such as total N fertilizer use (Kt) per country, and fertilizer consumption per crop (%) in the EU-27. At a national level most of the data is from well-established data sources.

In the ideal situation, the mineral N fertilizer use should be collected at the farm level (or plot level). However, the question is whether collection of mineral N fertilizer use on the farm level is needed and if a reliable estimates can be derived from large scale surveys. Ideally, it should be possible to disaggregate the nitrogen balance geographically (sub-nationally) and between sectors (dairy cattle, pigs etc), since policies designed to reduce the gross nitrogen balance would be more cost-effective if the sources of inefficiency can be identified (Task 1). There is no need for calculation of N balances on the farm level (although my provide insight in the N and P use efficiency and surplus on the balances for different farming types).

There are two approaches to derive estimates of mineral N fertilizers on regional scale and crop level in regions, i.e. up scaling of the results of surveys of mineral N fertilizer use on farms or downscaling (disaggregation) of the results of national fertilizer use to the regional level. The first approach demands for surveys on farms and additional resources to derive primary data. The second approach demands for a methodology to down scale national data on fertilizer use. Although disaggregation cannot be considered as primary data, the methodology is described in this paragraph. An approach to disaggregate scale mineral N fertilizer use from national level to crop and regional level was applied in the MITERRA-Europe model[93] and DNDC-CAPRI[94] model. In the UK TAPAS Action on Soil Nutrient Balances it was also indicated that more process-based models populated by purposely collected data need to be used at finer scales (e.g. catchments)[95].

In the MITERRA-EUROPE the national use of mineral N fertilizer is distributed over crops on country level using weighing factors. The weighing factors were calculated from the N demand of the crop (= N in harvested products + N in crop residues) and the total area of the crop. Moreover, the total manure N use on crops is estimated in MITERRA-EUROPE using expert judgement

Results of MITERRA-EUROPE are presented in Table 14. Is must be clearly stated that the methodology

[93] Velthof GL, D Oudendag, HP Witzke, WAH Asman, Z Klimont and O Oenema (2009) Integrated Assessment of Nitrogen Losses from Agriculture in EU-27 using MITERRA-EUROPE. Journal of Environmental Quality 38: 402-417.

[94] Leip, A., Marchi, G., Koeble, R., Kempen, Britz W. and Li. C (2008) .:Linking an economic model for European agriculture with a mechanistic model to estimate nitrogen losses from cropland soil in Europe. Biogeosciences, 5(1): 73-94A.

[95] David Fernall, and Alistair Murray (2009) UK TAPAS Action Soil Nutrient Balances. Final Report

applied in MITERRA-EUROPE can be improved by including N and P application standards for the Nitrates Directive and by involving agricultural experts from the EU-member states. However, the results indicate that there is scope to down scale national mineral N fertilizer to crop and regional level. The advantage of such modelling approach is that an uniform approach is used for all member states of EU-27.

There is considerable uncertainty in the estimated mineral N fertilizer use, based on such approach. However, the uncertainty in data based on surveys on farm level is probably similar, because farmers may be biased (i.e. under estimate) the N fertilizer use, especially in regions with N application standards of the Nitrates Directive. It is recommended to combine a method of downscaling national mineral N fertilizer use to crop and regional level and some small pilots with targeted surveys of mineral N fertilizer use on farms to check the results (and improve the methodology if needed).

The P fertilizer use is needed for the P balance and the risk of P leaching. In the ideal situation, the risk of P leaching (and need for P mineral fertilizer use) should be derived at farm scale, because risk of P leaching is controlled by local factors as P surplus, P status of the soil, soil type, crop type, slope, hydrology, etc. However, the determination of risk of P leaching on a farm scale is considered as long-term development, and not feasible for the short-term (because of the very detailed data needs).

For P fertilizer use, the similar approach as for N fertilizer use is recommended, i.e. scaling down the national P fertilizer use to crop and regional level, using information about P demand of crops, P fertilizer recommendations, P application standards, and manure use. Ideally, the down scaling of national data on mineral N and P fertilizer use is carried out with the same methodology.

Recommendations

- The total N and P fertilizer consumption is needed on regional scale, as the calculations for the N and P balances and ammonia and nitrous oxide emissions are based on regional and national scale. For the Nitrates Directive the amount of N fertilizer used in nitrate vulnerable zones is needed.
- For ammonia emission, the national use ammonium nitrate, calcium ammonium nitrate, anhydrous ammonia, ammonium phosphate, urea, urea-ammonium nitrate solution (UAN), and other N fertilizers is needed.
- For nitrous oxide emission, the total mineral N fertilizer use.
- The determination of risk of P leaching on a farm scale is considered as long-term development, and not feasible for the short-term (because of the need of very detailed data environmental conditions information). Therefore, it is recommended to derive P mineral fertilizer use on the regional level.
- Data from fertilizer producers and retailers (e.g. via EFMA) may be used, but may need a correction to translate fertilizer production in fertilizer consumption. EFMA provides statistics such as total N and P fertilizer use (Kt) per country, and fertilizer consumption per crop (%) in the EU-27.
- Ideally, it should be possible to disaggregate the N and P balance geographically and between sectors, since policies designed to reduce the surpluses on the N and P balances would be more cost-effective if the sources of inefficiency can be identified. There is no need for calculation of N and P balances on the farm level.
- It is recommended to derive a method of downscaling national mineral N and P fertilizer use to crop and regional level. The results should be checked with data from targeted surveys of fertilizer use on selected farms. This data can be used to improve the methodology if needed. Ideally, the down scaling of national data on mineral N and P fertilizer use is carried out with the same methodology.

Coefficients

The emissions of ammonia and nitrous oxide are calculated using emission factors (in percentage of the N applied). Default (Tier 1 or Tier 2) emission factors can be used, as presented in EEA/EMEP Guidebook (see Table 13), and IPCC Guidelines, or develop country specific emission factors. It depends on the chosen methodology, at what detail level emission factors have to be derived.

Recommendations:

- Use the default emission factor of ammonia and nitrous oxide (in % of the N applied) presented in EEA/EMEP Guidebook (see Table 13) and IPCC Guidelines.
- If data are available, derive country specific emission factors for ammonia and nitrous, e.g. dependent on factors as mineral N fertilizer type, manure N application technique, crop and soil type.

Table 14: Mineral fertilization application rates in kg N per ha in 2000 calculated with MITERRA-EUROPE (Velthof et al., 2007)[96]

This table is included as an example of scaling down national fertilizer to the crop level. The data must not be considered as a proposal for N application rates. In the ideal situation, a scaling down approach must be combined with data from surveys of fertilizer use on selected farm and estimates from country experts.

	AT	BG	BL	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IR	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Apples	9	4	15	5	14	7	12	1	6	1	3	9	6	5	9	1	19	0	2	15	3	2	1	5	39	10	4
Barley	28	21	65	13	44	90	68	12	25	4	65	67	32	62	36	19	86	7	39	78	37	11	9	43	35	24	46
Citrus Fruits				13					7	1		4			6				4			2					
Durum wheat	36	24		29		138			31	4		83	46		35							11	11			35	71
Flowers	59	68	62	121	101	121	84	52	85	11	149	85	96	61	80	71	91	34		76	120	56	37	88	131	62	62
Gras	58	57	153	102	101	156	210	47	72	10	144	96	96	110	72	57	123	27		210	120	51	34	99	131	56	86
Fodder maize	64	12	94		76	61	95	26	89	10		86	43	31	85	35	124	17		126	78	33	6	44	48	39	31
Grain maize	82	15	119		97	83			114	12		109	55		108	49	158			160	99	42	8		61	49	
Nurseries	59	68	62		101	121	84	52	85		149	85	96	61	80	71	91			76		56	37	88	131		62
Oats	27	9	54	18	38	91	55	13	21	3	68	49	20	68	24	15	71	7		74	28	9	5	44	22	18	49
Other cereals	33	21	57	63	46	75	60	27	45	3	78	51	30	32	42	19	76	8	34	65	37	10	19	46	35	32	46
Other crops	85	22	104	155	60	131	137	20	96	11	140	61	59	95	84	37	138	12	35	198	104	53	14	66	63	58	52
Other fodder crops	59	68	62	121	101	121	84	52	85	11	149	85	96	61	80	71	91	34	65	76	120	56	37	88	131	62	62
Other fruit	3	1	13	5	5	3	6	0	4	0	1	4	3	3	4	1	17	0	2	12	3	1	1	2	4	3	3
Other industrial crops	43	49	45	88	74	88	61	38	62	8	108	62	70	45	58	51	66	24		55	87	41	27	64	95	45	45
Olives for oil				69					49	6		48			45				37			32			1		
Other oils	59	68	62	121	101	121	84	52	85	11	149	85	96	61	80	71	91	34		76	120	56	37	88	131	62	62
Other vegetables	63	16	77	115	45	98	102	15	71	8	104	46	44	71	62	27	102	9	26	147	77	40	11	49	47	43	39
Paddi rice		40							80	9		68	44		61							42	12				
Potatoes	49	13	96	65	65	162	118	20	49	7	102	95	49	66	57	29	127	12	44	133	64	23	12	74	62	35	73
Pulses	39	8	86	40	64	146	78	22	39	2	95	107	44	101	35	33	113	16	58	129	62	9	9	59	71	32	70
Rape	44	25	69		86	123	95	19		5	61	77	44	68	28	29	92	13		115	78		12	68	64	37	57
Fodder roots	31	8	62	42	42	104	76	13	31	4	66	61	31	42	36	19	82	8	28	86	41	14	8	47	40	22	47
Ryem	23	7	37		41	79	51	11	19	2	40	44	21		27	17	50	7		56	24	6	6	53	33	17	44
Soya	61	20			65				81	10		107	62		140			19			68		10		56	71	35
Sugar beet	88	16	131		124	192	145	49	133	15	121	164	81	100	94	51	173	24		160	116	77	12	103	109	65	86
Sunflowes	41	14			65	72			31	3	89	60	42		48						72	8	8	53	68	18	37
Soft weat	28	24	83	29	62	138	93	13	31	4	73	83	46	90	35	29	110	16	43	118	51	11	11	71	60	35	71
Table olives									85	11		85			80							56					
Table grapes		68	62	121				52	85	11		85	96		80		91		65	76	120	56	37		131	62	
Flax and hennep	43	49	22		8		61	2	62	0	108	4	70		1	2		1		8	10		3	64		45	4
Tobacco	31	18	58	158		69			47	7		58	42		68						61	38	8			35	
Tomatoes	68	7	138	76	12	215	107	17	30	4	309	75	23	41	33	3	183	2	24	336	13	22	3	231	22	9	183
Wine (table)	59	68	62		101	121			85	11		85	96		80		91					56	37		131	62	62

[96] Velthof, G.L. D.A. Oudendag & O. Oenema (2007) Development and application of the integrated nitrogen model MITERRA-EUROPE. Task 1 Service contract "Integrated measures in agriculture to reduce ammonia emissions". Alterra report 1663.1, Alterra, Wageningen.

6.3.7 Biological N fixation and atmospheric deposition and associated N_2O emission

Step VII. Calculate the N (and P) inputs of other sources, such as biological N fixation and atmospheric deposition.

Primary data

For the calculation of the N and P balances also the inputs via other sources are required: biological N fixation and atmospheric N deposition, and other sources if relevant (e.g. composts). The data should be collected on the scale on which the balances are calculated i.e. crop, regional, and national scales.

There are several sources of biological N fixation, i.e. the fixation by free living soil bacteria, clover in grasslands, and other leguminous crops. The N fixed by free living soil bacteria is generally small, i.e. < 5 kg N per ha per year[97]), and can be neglected in the balance calculation. The amount of N fixed by clover is difficult to estimate, because both the estimate of the average share of clover in grassland in a region and the amount of N fixed by clover are uncertain. If clover is grown on soils that contain mineral N (e.g. because of N fertilizer or manure application), clover can use this N and may not or slightly fix atmospheric N. The best estimate of N fixed by clover can be made from local experts with knowledge of the grasslands and management of grassland. The N fixed by other leguminous, such pulses and soya, can be estimated as the N in the total crop (i.e. harvested products and crop residues). However, it must be noted that also these crops may partly use soil mineral N (in part from N applications) instead of fixing N.

For the atmospheric N deposition, local or European sources are available (e.g. the EMEP data base: http://www.emep.int/index_data.html). The atmospheric N deposition is strongly controlled by source of N emissions, such as industries, cities, and traffic, and livestock. If the N balance is calculated on the regional level, it is recommend to collect data on atmospheric N deposition on the regional scale (and especially for countries with large spatial differences in atmospheric deposition). The atmospheric P deposition is small and can be neglected in the P balance calculations.

The use of organic N products such compost and sewage sludge may be locally important for the N and P balance, but may also influence soil quality, because of inputs of organic carbon (positive effect) and heavy metals, antibiotics, hormones, etc (negative effects). It is recommended to derive estimates of the total use of organic products in countries or regions from companies that produce/sell these products, such compost producers, and water purification plants. The European Compost Network (ECN) is a collaboration of partners, promoting sustainable practices in composting, anaerobic digestion and other treatment procedures for organic residues across Europe (http://www.compostnetwork.info/index.php?id=9). On this website, estimates are presented of the use of compost in 25 EU countries.

Coefficients

The use of compost and other organic products are probably expressed in tonnes product. Estimates of the N and P (and organic C and heavy metals) should be derived by a literature/desk study to derived average (default) values if these contents are not available.

[97] Paul, E.E., and F.E. Clark. 1996. Soil microbiology and biochemistry. 2nd ed. Academic Press, San Diego, CA.

Recommendations

- The best estimate of N fixed by clover can be made from local experts with knowledge of the grasslands and management of grassland.
- The N fixed by other leguminous, such pulses and soya, can be estimated as the N uptake of the total crop.
- The N fixed by free living soil bacteria is generally very small, i.e. < 5 kg N per ha per year, and can be neglected in the balance calculation.
- It is recommend to collect data on atmospheric N deposition on the regional scale (and especially for countries with large spatial differences in atmospheric deposition). Local and European sources of N deposition are available.
- The atmospheric P deposition is small and can be neglected in the P balance calculations.
- It is recommended to derive estimates of the total use of organic products in countries or regions from companies that produce/sell these products, such compost producers, and water purification plants. The European Compost Network (ECN) may be a source of information (http://www.compostnetwork.info/index.php?id=9).
- The use of compost and other organic products are probably expressed in tonnes product. Estimates of the N and P (and organic C and heavy metals) should be derived by a literature/desk study to derived average (default) values if these contents are not available.

Coefficients

The emissions of ammonia and nitrous oxide are calculated using emission factors (in percentage of the N applied). Default (Tier 1 or Tier 2) emission factors can be used, as presented in IPCC Guidelines, or develop country specific emission factors. It depends on the chosen methodology, at what detail level emission factors have to be derived.

Recommendations:

- Use the default emission factor of ammonia and nitrous oxide (in % of the N applied) presented in EEA/EMEP Guidebook (see Table 13) and IPCC Guidelines.
- If data are available, derive country specific emission factors for ammonia and nitrous, e.g. dependent on factors as mineral N fertilizer type, manure N application technique, crop and soil type.

6.3.8 Nitrogen balance

Step VIII. Calculate the N balance

Primary data

The surplus of the AEI 15 *N balance* is calculated as the difference between N inputs and N outputs on the soil balance.

The data required to calculate the N inputs are

- Manure N applied (**Step IV**). For the gross balance for OECD, the gaseous N losses during housing and from manure stored should not be extracted from the excretion).
- N excreted during grazing (**Step V).**

- Mineral N fertilizer application (**Step VI**).
- Biological N fixation (**Step VII).**
- Atmospheric N deposition (**Step VII).**

The data required to calculate the N outputs are:

- N removed by harvested crop products, calculated from the yields and the N contents of the harvested products per year, crops (including catch crops and winter crops; soil cover) and grassland area. The AEI 7 *Irrigation* can be used to estimate the yield. The share of irrigable areas in the total area used for agriculture (main indicators) and for supporting indicators information about irrigated areas, irrigated crops, and, irrigation methods have to be included.

Estimates of the yields on regional level are required to set up N and P balances on the regional level. The harvested yields (i.e. removed from the field) have to be used on regional or national scale (depends on the size of the country). The current yields estimates of Eurostat could be used for the balance calculations. Eurostat only reports the yields of the main crops (which may differ between countries). However, this is sufficient for the calculations of N and P balances as the N uptake by minor crops does not significantly affect the total N uptake in a region or country.

Accurate yields of grasslands are lacking, but are needed to obtain soil N and P balances. The difficulty in estimation of grassland yields is that there is a huge difference in management and yields. Grasslands range from rough grazing (low yields) to intensively managed grasslands (high yields). Estimates of the area and yields of different types of grasslands are needed.

Eurostat defines grassland, as land used permanently (for 5 years or more) to grow herbaceous forage crops, through cultivation (sown) or naturally (self-seeded) and that is not included in the crop rotation. Grassland consists of pasture, meadow and rough grazing. Rough grazing is low yielding permanent grassland, usually on low quality soil, for example on hilly land and at high altitudes, usually unimproved by fertilizer, cultivation, reseeding or drainage. These areas can normally be used only for extensive grazing and are not normally mown or are mown in an extensive manner; they cannot support a large density of animals.

In the model MITERRA-EUROPE grassland yields are estimated. Three types of grasslands are distinguished: intensively managed grasslands, extensively managed grasslands, and rough grazing. The percentage of intensively managed and extensively managed grasslands are estimated and those of rough grazing derived from Eurostat. For Belgium, Denmark, and the Netherlands it was assumed that 75% of the managed grasslands is intensively managed, for Ireland this is 50%, and for the other countries 25%. These estimates are based on expert knowledge, the pastoral type map of the European pasture monograph and pasture knowledge base of the Pask study of JRC, as well as the assumption that the proportion of intensively managed grasslands decrease with increasing size of the country. Table 15 shows the estimates of grassland yields made in MITERRA-EUROPE.

Another example is the study of Aarts et al. (2008)[98] in the Netherlands, in which the grassland yield was estimated on farm level using data on milk production, energy requirements, feed composition, and maize yields. The grassland yield was the output of a balance calculation. Such a calculation can be also made on a regional level, but a methodology must be derived. Evidently, these mean yield estimates should have a firm and scientifically sound underpinning.

It also recommended to assess if the estimates and forecasts made by the Monitoring Agricultural ResourceS (MARS) Unit of JRC can be used as a source of yields or validation of yields. The AGRI4CAST system, also known as the MARS Crop Yield Forecasting System, is made by remote sensing and meteorological observations, agro-meteorological modelling (Crop Growth Monitoring System (CGMS), MARS Model Library) and statistical analysis tools http://mars.jrc.it/mars/About-us/AGRI4CAST).

Table 15: Estimates of dry matter and N contents of grassland and proportion of grassland types

Country	nett dry matter yield,		N content, % DM		proportion, % of total grassland area			average dry matter yield	average N content, % DM	average N yield, kg N per ha
	intensively managed	extensively managed	int	ext and rough grazings	intensive	extensive	rough grazing			
Austria	6000	3000	3	2	13	40	47	3750	2.25	84
Belgium	9000	4500	3	2	75	25	0	7875	2.75	217
Bulgaria	4000	3000	3	2	17	52	31	3250	2.25	73
Cyprus	4000	3000	3	2	17	51	32	3250	2.25	73
Czech rep.	5000	3500	3	2	25	74	1	3875	2.25	87
Denmark	9000	4500	3	2	73	24	2	7875	2.75	217
Espagne	5000	3000	3	2	12	35	53	3500	2.25	79
Estonia	5000	3000	3	2	25	75	0	3500	2.25	79
Finland	6000	3000	3	2	21	63	16	3750	2.25	84
France	7000	3500	3	2	8	24	68	4375	2.25	98
Germany	8000	4000	3	2	24	73	3	5000	2.25	113
Greece	4000	3000	3	2	8	24	68	3250	2.25	73
Hungary	5000	3500	3	2	14	42	44	3875	2.25	87
Ireland	8000	4500	3	2	43	43	15	6250	2.50	156
Italy	5000	3000	3	2	20	59	21	3500	2.25	79
Latvia	5000	2500	3	2	4	13	83	3125	2.25	70
Lithuania	5000	2500	3	2	25	75	0	3125	2.25	70
Luxembourg	9000	4000	3	2	25	75	0	5250	2.25	118
Malta	4000	3000	3	2	25	75	0	3250	2.25	73
Netherlands	10000	5000	3	2	72	24	4	8750	2.75	241
Poland	5000	3500	3	2	18	54	28	3875	2.25	87
Portugal	5000	3000	3	2	7	22	71	3500	2.25	79
Romania	5000	3000	3	2	23	70	7	3500	2.25	79
Slovakia	5000	3000	3	2	23	69	9	3500	2.25	79
Slovenia	5000	3500	3	2	21	63	16	3875	2.25	87
Sweden	7000	3500	3	2	23	68	9	4375	2.25	98
United Kingdom	8000	4500	3	2	14	43	43	5375	2.25	121

Source: MITERRA-EUROPE

There are no EU wide data sets on irrigated areas quantifies of total water consumption on small spatial scale (crop or farm level) available. It is recommended to collect data in targeted farm surveys every five years. The collected data should include data on:

- The areas equipped with irrigation facilities;
- The areas and types of crops actually irrigated;
- The area covered by different types of irrigation installation, i.e. srinklers, drip irrigation,

[98] Aarts, H.F.M, C.H.G. Daatselaar & G. Holshof (2008) Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmaïs op melkveebedrijven. Rapport 208, Plant Research International.

flood irrigation, and other types of irrigation

For the short time, it is recommended to use the current FSS data set on (1) total irrigable area (area covered with irrigation infrastructure), total cultivated area irrigated at least once a year (actual irrigated area), and (3) cultivated area of 10 main crops irrigated at least once a year.

Recommendations

- The harvested yields (i.e. removed from the field) have to be used on regional or national scale (depends on the size of the country). The current yields estimates of Eurostat can be used for the balance calculations.
- Accurate yields of grasslands are lacking, but are needed to obtain data for the N and P balances. A methodology should be developed to estimate the grassland yields in different countries/regions in EU-27, taking the different management types into consideration (rough grazing, extensively managed, and intensively managed).
- It also recommended to verify if the estimates and forecasts made by the Monitoring Agricultural ResourceS (MARS) Unit of JRC can be used as a source of yields or validation of yields.
- For irrigation, it is recommended to use on the short term the current FSS data set on (1) total irrigable area (area covered with irrigation infrastructure), total cultivated area irrigated at least once a year (actual irrigated area), and (3) cultivated area of 10 main crops irrigated at least once a year.
- It is recommended to collect irrigation data in targeted farm surveys every five years. The collected data should include data on:
  - The areas equipped with irrigation facilities;
  - The areas and types of crops actually irrigated;
  - The area covered by different types of irrigation installation, i.e. sprinklers, drip irrigation, flood irrigation, and other types of irrigation

Coefficients

For all crops, estimates of the N and P contents are needed. It is well-known that the N content of crops and crop residues is related to the N input. Therefore, it is recommended to carry out a desk study to obtain the N and P contents in the crop products in different regions in EU and/or in dependency of the N and P inputs. The average values can be used in the N and P balance calculations. Example of sources of N and P contents of crop products are Fink et al. (1999)[99] and Greenwood and Draycott[100].

Recommendations

- It is recommended to carry out a desk study to obtain the N and P contents in the crop products in different regions in EU or in dependency of the N and P inputs.

[99] Fink, M., C. Feller, H.C. Scharpf, U. Weier, A. Maync, J. Ziegler, P.J. Paschold, and K. Strohmeyer. 1999. Nitrogen, phosphorus, potassium, and magnesium contents of fi eld vegetables- recent data for fertiliser recommendations and nutrient balances. J. Plant Nutr. Soil Sci. 162:71–73.

[100] Greenwood, D.J., and A. Draycott. 1989. Experimental validation of an N response model for widely diff erent crops. Fert. Res. 18:153–174.

6.3.9 Risk of phosphorus leaching

Step IX. Calculate the risk of phosphorus leaching.

The surplus on the P balance is the main indicator for risk of P leaching, i.e. the difference from the P inputs via i) mineral fertilizer, ii) manure, and iii) grazing and the P output via crop removal, including the P removed by cut or grazed grass. However, the pathway of P losses from agriculture to the environment is very different from that of N losses. Only a P surplus is insufficient for assessing the environmental risk. Therefore, the risk of P pollution needs to be assessed on the basis of "P surplus on agricultural land" and a supporting indicator "Vulnerability to P leaching/run-off". The actual P loss from agricultural land to surface waters is a complex function of climate, topography, soil type, soil P status, P fertilization, and land management. These factors vary greatly in space and over the year, and the hydrological pathways for P losses also vary greatly in space and time. The effects of these individual factors on P loss from agricultural land to surface waters are rather well understood, but in combination the understanding is less well developed. As a consequence, current simulation models do no simulate the actual P loss from agricultural land to surface waters very accurately yet.

Required data

For the P balance data on P input and outputs are required:

P inputs

- Manure P applied (**Step IV**);
- P excreted during grazing (**Step V)**;
- Mineral P fertilizer application (**Step VI**).

P outputs:

- P removed by harvested crop products (yields), calculated from the yields and P contents of the harvested products per year, crops (including catch crops and winter crops; soil cover) and grassland area (**Step X**).

Estimation of the vulnerability of agricultural land to P leaching and run-off to the aquatic environment requires a huge amount of spatially and temporally explicit data (See Task 1 of DireDate). The following (combination of data) are helpful to improve the estimate of the risk of P leaching in combination with the P surplus:

- The P status of soils (soil test P values, P saturation index and P sorption capacity). A Potential data source is LUCAS 2009 soil samples (JRC)
- Crop management; cropped and fertilised area (ha).
- Amounts of fertilizer and manure P applied
- Amounts of fertilizer and manure P applied in the past
- Soil texture (Potential data source – European Soil Database (JRC)
- Tillage and cropping practice.
- Climate: total rainfall and its distribution over the year and irrigation affect the hydrological pathways and the vulnerability to leaching and runoff.
- Topography: surface and subsurface runoff depend to a large degree on terrain attributes

like slope gradient and upslope contributing area as well as the distance of effective discharge and eroding areas to water courses.

In order to estimate share of the different tillage practices, the following data are needed per farm:

- Area managed by reduced tillage, i.e., without ploughing.
- Area managed by zero tillage (direct seeding).
- Area managed by conventional tillage, i.e., with ploughing.

Collecting the data required for this indicator via the Farm Structure Survey (or SAPM) would be sufficient since tillage practice does not change significantly from year to year. The indicator should be available on a regional level. .

AEI 26 Soil quality does not yet have an approved definition and description and therefore it is not possible to define the data requirements. However, for estimating the risk of P pollution, the soil P status and the soil texture are recommended to be collected.

6.3.10 Nitrate pollution

Step X. Nitrate pollution

This steps requires the collection of water quality data obtained in monitoring of ground water and surface water. The European Environment Agency (EEA) have recently published databases on the status and quality of water bodies across Europe, which incorporate data collected annually through WISE, including data reported for Water Framework Directive and Nitrates Directive. There are three datasets publicly available via WISE, i.e. lakes, rivers, and groundwater', all of which contain data on nitrate concentrations along with monitoring site attribute data (including point location). The data sets include long time-series of data updated annually. All sources of monitoring data meeting the required quality standards are consolidated into one database. The member states have obligations to monitor water quality (Nitrates Directive and Water Frame Work Directive) and report the results in a fixed format to the European Commissions. EEA and DG Environment coordinate activities to streamline the different reporting systems.

The data set contains nitrate concentration from multiple sources, not just agriculture. The monitoring data for the Nitrates Directive contains data for water quality in areas affected by agriculture.

6.3.11 Total ammonia emission

Step XI. Total ammonia emission

The total ammonia emission is calculated as the sum of the emission from housing and manure storage (**Step III**), manure application (**Step IV**), grazing (**Step V**), and mineral N fertilizer (**Step VI**). No additional data are needed.

6.3.12 Greenhouse gas emissions

Step XII. Greenhouse gas emissions

The total sum of greenhouse gas emissions in the sum of the nitrous oxide, methane and CO_2 emissions. In this report, the non-CO_2 greenhouse gas emissions are considered.

The total direct nitrous oxide emission is calculated as the sum of the emission from housing and manure storage (**Step III**), manure application (**Step IV**), grazing (**Step V**), and mineral N fertilizer (**Step VI**). No additional data are needed

The total methane emission is calculated as the sum of the methane emission from livestock (enteric fermentation; **Step II**) and storage of manure (**Step III**). Notice that wetland rice is also a source of methane, but in EU the area of wetland rice is limited (some regions in Italy and Spain). Wetland rice is not included in this report, but countries with wetland rice have to include the emission in the calculation of total methane emission.

Moreover the indirect nitrous oxide emission (i.e. the emission related to ammonia emission and nitrate leaching) have to calculated as:

- Total ammonia emission (**Step XI**) and the emission factor for the indirect nitrous oxide emission from ammonia.
- Total N input to the soil (see **Step VIII**), the leaching fraction (the $FRAC_{leach}$ factor of IPCC), and the emission factor for the indirect nitrous oxide emission from nitrate.

Coefficients

Required coefficients:

- The emission factor for the indirect nitrous oxide emission from ammonia,
- The emission factor for the indirect nitrous oxide emission from nitrate,
- The leaching fraction (the FracLEACH factor of IPCC).

In the IPCC methodology a leaching fraction (FracLEACH) is used to estimate the nitrate leaching via leaching and runoff. The leaching is multiplied with an emission factor for indirect N_2O emission from leaching to groundwater and surface drainage, rivers, and coastal marine areas. IPCC has changed it methodology for calculation of FracLEACH in the guidelines of 2006[101] in comparison with the guidelines of 1996[102]. The underpinning of the calculation of indirect N_2O emission is better in the guidelines of 2006 than of 1996. However, countries have to use the guidelines of 1996, except that they can show that the method and emission factors according to guidelines of 2006 are more reliable than those of the guidelines of 1996. Most of the countries reporting greenhouse gas emissions, use default values for FracLEACH (0.3) and the emission factors of the previous IPCC methodology (2.5% of leached N). Some countries use models or country specific FracLEACH factors to calculate leaching (e.g. Belgium-Flanders, Denmark, Finland, and the Netherlands).

[101] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf

[102] http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch4ref7.pdf

Recommendations:

- Use the default emission factors for indirect N_2O emission nitrous oxide presented in the IPCC Guidelines.
- Use the default leaching fraction of the IPCC Guidelines.
- If data are available, derive country specific indirect N_2O emission factors related to ammonia emission and nitrate leaching.
- If data or methods are available, a country specific N leaching or FracLEACH can be derived.

6.4 Screening of required level of detail for the other Agri-environmental Indicators

In paragraph 5.4, the remaining AEIs were grouped in four categories, i.e.

I) AEIs linked with the AEIs in Figure 8,

II) AEIs related to the use of pesticides,

III) AEIs related to energy, and

IV) AEIs related to land use and ecological aspects of farming systems.

Re I. AEIs linked with the AEIs in Figure 8:

- AEI 13. *Specialisation*
- AEI 12. *Intensification/extensification*
- AEI 20. *Water abstraction*

None of the reviewed agri-environmental policies require data on AEI 13 specialisation as defined in this AEI (DireDate Task 2), but several policies are affected by this indicator (e.g. Birds and Habitats Directive, Water Framework Directive, Nitrates Directive, Framework Directive for the Sustainable use of pesticides.). Data for this indicator are available from the annual Farm Structure Survey (FSS). Moreover, the AEI 13 specialisation' is directly linked to many of the other indicators (See report of Task 1 of DireDate).

There are some conceptual and technical bottlenecks for AEI 12 *Intensification/extensification* (See report of Task 1 of DireDate).The following data have to be collected at least for AEI 12 *Intensification:*

- Input of mineral fertilizers, energy and pesticides in amounts per hectare and per land use type
- Livestock density and amounts of purchased feed;
- Ratio between input and output in monetary terms

The data for mineral fertilizers, energy and pesticides need to be collected also for the AEIs 5, 6, and 8. The livestock density is also collected (AEI 10.2). The required data for calculation of the indicator in monetary terms is collected through the FADN, which is an instrument for evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy, and collects data from a sample of the agricultural holdings in the EU. FADN data can be used as a basis for the intensity typology, and are routinely collected. At the short term, it is recommended to use the current FADN data collection. On the long term, the FADN sample may be extended, so that also all environmentally relevant farms are included (including also the smaller and part-time farms, and farms that are below the current economic size threshold).

Agri-environmental policies that require data on agricultural water use (AEI 20 *Water abstraction)* include (see Report of Task 2 of DireDate) the Water Framework Directive, and Sustainable Development Indicators. It is recommended to use the current reporting systems (FSS, OECD/Eurostat Joint Questionnaire on Inland Waters, LUCAS, AQUASTAT, JRC database and WFD reporting (See report of Task 1 of DireDate), although it is known that most of the data collected are available at a very coarse level and are collected on an irregular basis.

Re II. AEIs related to the use of pesticides:

- AEI 6 *Pesticide consumption*
- AEI 17 *Pesticide risk*
- AEI 27.3 *Pesticide in water*

Data required for this AEI are being collected under Regulation 1185/2009 concerning statistics on pesticides (see DireDate Task 2). Data on pesticide consumption should be supplied for selected crops in one year of each five-year reporting period. Data collection can be based on surveys, administrative sources or a combination of different means including statistical estimation procedures. Countries have to collect data from 2015 at national level on a mandatory basis for a one-year reference period every five years. Member States will be allowed to target the appropriate crops for their region. For the short term there are no additional recommendations to improve data collection for pesticide use. On the long term, the surveys may be extended (i.e. more frequent sampling and sampling of more active substances). Sources that are used are sales data, individual Member State surveys, FADN (use of pesticides, expressed in monetary terms).

It is recommended to quantify AEI 17 *Pesticide risk*, using the modelling framework HAIR (Harmonised environmental indicators for pesticide risk) which is developed by DG JRC. The HAIR databases and software includes data on pesticide use (linked to AEI 6 *Pesticide consumption*), agricultural practice, land use, GIS information and ecotoxicology. Finest resolution available is currently the catchment scale. For the long-term, it is recommended to develop HAIR at a finer resolution, but this requires detailed information of tillage and cropping practice: pesticide application, drainage, topography, and soil type.

For AEI 27.3 *Pesticide in water*, the data of monitoring of surface water quality can be used, as published by EEA in the WISE data base. There are three datasets publicly available via WISE. 'Waterbase – Lakes', 'Waterbase – Rivers' and 'Waterbase – Groundwater', all of which contain data on concentrations of priority and other chemical substances along with monitoring site attribute data (including point location).

Re III. AEIs related to energy:

- AEI 8 Energy use
- AEI 24 Production of renewable energy

The Sustainable Development Indicators demand for data on energy use. Information is required on final energy consumption by sector by energy source at a country level. The main indicator refers to total use of fossil energy at farm level. There is discussion about the need to include indirect energy use in the definitions. Data on energy are collected by Eurostat (Eurostat Energy Statistics). This system has a full EU coverage, but the main focus is on industry and households. The FADN collects data from a sample of the agricultural holdings in the EU. Energy consumption could be estimated from expenditure data in FADN in combination with energy prices collected by Eurostat. The necessary data to calculate energy unit costs and estimate energy consumption are available with annual updates. However, FADN data are not representative for the whole farming population.

The present data available are not consistently collected throughout the EU and can only be obtained from rare and scattered national and regional sources. For the estimation of heat and power generation by agricultural sources, data are very scarce as installations can both be small (decentralised) or large and rely on a very wide range of sources both from agricultural, forest and waste sectors both domestically based or imported. It is recommended to install a working group that reviews the gaps in data of energy use (based on Eurostat Energy Statistics and FADN), and that give recommendation for improvement of collection of data of energy use by agriculture. At the short term, the current data collection systems can be used, as they provide the required estimates of energy use by agriculture for Sustainable Development Indicators.

The indicator AEI 24 *Production of renewable energy* has relevance for several policies, including the Sixth Environmental Action Programme, United Nations Framework Convention on Climate Change, and 6th Environmental Action Programme.

The Sustainable Development Indicators requires data on the share of renewables in gross inland energy consumption at a national scale every 2 years. Ideally, the following data should be collected at farm level each year: i) type and area of targeted biomass cropping and ii) amount of harvested primary and secondary biomass feedstocks converted into bioenergy at farm and outside the farm (this includes oil, starch, sugar feedstocks for biofuel, ligno-cellulosic/woody material from primary (crops) and secondary (e.g. straw, cuttings) sources, manure).

There are several collection systems in place, including ePure, EBB and the Eurobserv'ER (data on fuel, bioethanol, biodiesel and biogas production, and AEBIOM of the European Biomass Association (compilation of all data available from EU and national sources). Although the available data are not consistently collected throughout the EU (based on rare and scattered national and regional sources) they provide the data required for the different policies. On the long-term, it is recommended to improve the data collection systems in order to get better cover of data over EU and to improve the quality of the estimates of the different renewable energy sources. There is a clear linkage between this indicator and the AEI 10.2 *Cropping patterns*.

Re IV. AEIs related to land use and ecological aspects of farming systems:

- AEI *1 Agri commitments*
- AEI 3 *Farmers training*
- AEI 4 *Area under organic farming*
- AEI 2 *Agricultural areas under Natura 2000*
- AEI 9 *Land use changes*
- AEI 14 *Risk of Farmland abandonment*
- AEI 22 *Genetic diversity*

- AEI *23 High nature farmland*
- AEI 28 *Landscape*
- AEI 25 *Farmland birds*

All these AEIs are part of the second set of AEIs, which means that these indicators are not directly collected by farmers, but that they are derived from additional sources and indirectly also from existing sources (mainly FSS and FADN). AEI 1 *Agri commitments* is a response indicator together AEI 2 *Agricultural areas under Natura 2000*, AEI 3 *Farmers training*, and AEI 4 *Area under organic farming.* Existing data sources are administrative data collected to monitor the implementation of rural development programmes. The quality of the data is considered as quite low. Data for *Farmers training* are collected in the Common Monitoring and Evaluation Framework (CMEF), which is compulsory to report under the Rural Development programming period 2007-2013. Also FSS provides information on farm management practices. The *Area under organic farming* is collected in FSS and FADN. A Eurostat Task Force met in May 2009 to discuss the data collection, the outcome of which instigated the preparation of a new questionnaire.

Agricultural areas under Natura 2000 serves as input to AEI 23 *High Nature Value farmland*, AEI 12 *Intensification/extensification*, and AEI 14 *Risk of farmland abandonment.* There also linkages to other AEIs, as the type of farm management in Natura 2000 areas is needed, which demands for information of stocking density, fertilized area, amount of fertilizer applied, and pesticide application. To estimate the types of land use in Natura 2000 areas, GIS datasets of land cover and Natura 2000 sites are required. The former is available from the 2006 Corine Land Cover (CLC) raster dataset. However, CLC does not provide the required level of detail to spatially define area. Data obtained at farm level of the area located in a Natura 2000 site would be ideal.

The AEI *Land use change* does not serve as an input to other AEIs, but it has indirect links to all AEI indicators, with land use area as denominator. It has links to AEI 2 *Agricultural areas under Natura 2000*, AEI 11.1 *Soil cover*, AEI 10.1 *Cropping patterns*, AEI 14 *Risk of farmland abandonment*, AEI 23 *High nature value farmland*, and AEI 28 *Landscape*. The Corine Land Cover is the most useful data sources for this indicator. Other land use data are collected in LUCAS, Agricultural surveys, and reporting for LULUCF. Improvements in data related to *Land use change* should be made for the distinction between types of grassland, the distinction between agricultural land and recently abandoned land. Moreover, different Member States may use slightly different definitions, classification and interpretations for extensively used grassland, high-nature farmland, nature conservation land and abandoned land. This demands for harmonization of definitions.

The indicator *Risk of Farmland abandonment* is not yet developed, but this AEI has links to AEI 11 Soil cover, AEI 9 Land use change, AEI 21 Soil erosion, AEI HNV farmland, and AEI 25 Population trends of farmland birds. The AEI *Population trends of farmland birds* is mature and the methodology has continuously been improved. The AEI *Landscape* has links to many other AEIs , but due to the complexity of European landscapes this AEI is difficult to capture by a single or even a group of parameters/indicators.

7 Recommendations

7.1 Introduction

In the DireDate project a prime focus was on AEIs related to nitrogen (N) and phosphorus (P) balances and greenhouse and ammonia emissions, as several EU policies demand these data. Thus, the collection of data and derivation of coefficients related to N and P balances and ammonia and greenhouse emissions have high priority (see Figure 8).

Moreover, in Task 2 it was concluded that the AEIs related to manure and fertilizer have the most in common with policy data requirements and that they have coefficients represented across multiple policies include the following. These are the AEIs

- 5. *Mineral fertilizer consumption*
- 10.2. *Livestock patterns*
- 11.3. *Manure storage*
- 15. *Gross nitrogen balance*
- 19. *GHG emissions*
- 27.1. *Water quality – Nitrate pollution*

Thereby, AEI 17 *Pesticide risk* also is required by several policies.

In this Chapter recommendations are given for the collection of data for the estimation of the AEIs indicated in Figure 8 (Building block principle; See Paragraph 2.2). These recommendations are also based on the findings of Tasks 1, 2, 3, 6 and 7, as discussed in part in earlier Chapters in this report. In the various meetings with Eurostat and members of national statistical offices it was clearly indicated that efficient systems of data collection are needed, which preferably decrease the burden of data collection and processing. Therefore, collection of data which are not yet covered by current systems should only be carried out when they have a high priority or when they replace the collection of other data. Moreover, data that are already collected should be used more efficiently (Effectiveness and efficiency principles; see Paragraph 2.2), and where possible also for other purposes, e.g. by disaggregation of data collected on a national scale to a regional scale (Multiple solutions principle; see Paragraph 2.2).

Highest priority should be given to the collection of those data that have largest effects on the N and P balances and ammonia and greenhouse emissions. The following type of data can be distinguished:

- Data related to inputs of N and P to agricultural systems, as they strongly affect both N and P balances and ammonia and greenhouse gas emissions (i.e. First things-first principle; see Paragraph 2.2).
- Data and coefficients related the emissions of ammonia and greenhouse gases, i.e. factors that determine the emissions that occur from manure and N fertilizers, such the type of housing, manure storage, and application technique.

- Data and coefficients related to the output of N and P in the gross N and P balance, i.e. the N and P in harvested crop products.

7.2 Data related to inputs of manure and fertilizer use

7.2.1 Data and coefficients

In table 16 a summary is given of the recommended collection of data and coefficients related to inputs of N and P, while Annex 1 provides a detailed listing of all the basic data that need to be collected. Good systems for collecting data on the number of livestock of a farm level are already in place (Primary source principle; see paragraph 2.2) However, efforts are required to improve and harmonize the estimates of the N and P excretion of livestock. It is recommended to obtain regional specific N and P excretion rates, especially in the case of dairy and beef cattle, on the basis of uniform and analytical sound methodologies. It is recommended to install a working groups of scientists to be able

1. To develop a method to calculate N and P excretion at regional level, based on inputs and outputs at the animal level (Taks 3 of DireDate).
2. To derive N and P excretion rates for each livestock category on the basis of the aforementioned method and required data.

Moreover, it is recommended to explore FSS/SAPM if these systems contain information that can be used to calculate the amount of manure excreted during grazing. If this is not the case, recommendations must be given to collect data on grazing and housing days in FSS.

Based also on discussions during the DireDate Expert Meeting in Brussels in December 2010, it is recommended to obtain the use of mineral N and P fertilizers by a combination of i) national consumption statistics, ii) disaggregation procedures, iii) expert judgments, and iii) targeted survey of fertilizer use on specific farms to validate and improve the estimates. It is recommended to

1. To improve the estimates of national fertilizer consumption statistics by consulting Fertilizers Europe (former EFMA) and (supra) national associations of fertilizer trading companies .
2. To install a working group of scientists, statisticians, and agronomists to set up a methodology to disaggregate national fertilizer consumption to crop level at NUTS II level. Data of N and P fertilizer recommendations, N and P application standards, crop yields and requirements of N and P, and manure use should be used to disaggregate the national consumption estimates. Local experts should be asked to review (and adjust) the estimates of crop-specific fertilizer application rates.
3. To set up and execute targeted surveys with the aim to validate (and possibly improve) the methodology of downscaling national fertilizer consumption statistics.

Total N fertilizer use per year should be split-up into different types of N fertilizer, as N fertilizer type has a large effect on ammonia emission. It is recommended to collect data for the following N fertilizer types: urea, urea-ammonium nitrate solution (UAN), anhydrous ammonia, (calcium) ammonium nitrate, other ammonium-based fertilizers (e.g., ammonium phosphates and ammonium sulphates), and other N fertilizers. For phosphorus fertilizers, the total P use is needed, because the type of P fertilizer does not influence the calculation of P balances.

The N fixed by leguminous crops can be estimated from the yield and N content of the leguminous crop. The amount of N fixed by clover in clover-grassland is difficult to estimate; it depends on the standing biomass of clover in the sward, which may vary throughout the year. Large amounts of N can be fixed in clover grassland (>200 kg N per ha per year) and care should be taken to identify these grassland and estimate its biological N fixation. It is recommended that agronomists of each member states set up a procedure/methodology for estimating the biological N fixation by clover-grassland swards on a regional level. The procedures and methodologies should be reviewed.

For atmospheric N deposition, it is recommended to use the EMEP data base (www.emep.int).

7.2.2 Approaches and procedures

This paragraph summarizes the recommendations related to the N and P input data collection and processing. It also briefly summarizes the possible consequences of these recommendations.

- Each Member State should establish a working group of experts related to the derivation of N and P excretion rates, for all livestock categories. This working group should establish the methodology, and once approved should use this methodology for estimating the N and P excretion rates each year, for all livestock categories. The methodology as well as the annual N and P excretion rates, for all livestock categories, should be made available to others and should be used for all policy reports (e.g. Nitrates Directive, National Emission Ceilings Directive, UNFCCC, UNECE-CLRTAP, Rural Development Program, Sustainability Indicator, N and P balances for OECD, FAO, etc.).
- There are no recommendation about changing the number of livestock in FSS. It recommended that Eurostat takes the lead in exploring the possibility (and reliability) to use the livestock registers for the number of cattle, pigs, sheep, goat, and horses. This should be carried in close corporation with the member states.
- Eurostat has to explore if SAPM can be used for estimating the grazing days. If not, recommendations should be made how to collect grazing days in FSS.
- The collection and processing of N and P fertilizer use, demands for several actions:
  - Improve the statistics of national fertilizer consumption. This has to be done by the member states, together with Eurostat, in consultation with Fertilizers Europe (EFMA) and (national) fertilizer trading associations.. The first step is that the member states indicate the uncertainties and difficulties in obtaining data on fertilizer use in their country. Part of possible problems will be country-specific, but part of the problems will be the same for several member states. It is recommended that Eurostat and FAO make a synthesis of the problems related to collecting data of fertilizer consumption, and discuss this with Fertilizers Europe (EFMA). EFMA already has a fertilizer statistics in place, which can help to improve the quality of the estimates of different member states (http://www.fertilizerseurope.com).
  - Each Member State should establish a working group of experts to derive a methodology to disaggregate national fertilizer consumption data to crop-specific data at regional scale (NUTS-2). This is a temporal activity, and can be done in a project. However, management and improvement of the methodology is a permanent activity and must be carried out preferably by the working group of experts or by a research institution.

- Set up of targeted surveys to validate and improve the methodology of deriving crop-specific and regional-specific N and P fertilizer use data on the basis of the disaggregation of national fertilizer consumption statistics. The set-up of these surveys is dependent on the results of the developed disaggregation procedure. It is recommended that National statistical offices will carry out these surveys and process the data, as they have most experiences in surveys. However, the validation of the methodology and improvement of the estimates should be carried out by scientists (working group) involved in the development of the methodology.
- The application of the methodology for deriving crop-specific and regional-specific N and P fertilizer use data should be done by the national statistical offices.
- The methodology as well as the annual crop-specific and regional-specific N and P fertilizer use data should be made available to others and should be used for all policy reports (e.g. Nitrates Directive, National Emission Ceilings Directive, UNFCCC, UNECE-CLRTAP, Rural Development Program, Sustainability Indicator, N and P balances for OECD, FAO, etc.).

- Each Member State should establish a working group of experts (agronomists) to establish a methodology for the derivation of N fixation by clover in grasslands. It is also recommended to organize a workshop at EU-27 level with all scientists and agronomists involved, in order to discuss and approve the methodologies and to derive the best estimates of N fixed by clover on regional level in EU-27.
- Data of dry and wet N deposition are available at EMEP-website at different spatial and temporal scales. It is recommended that Eurostat consults EMEP about use of N deposition data in the calculation of the N balances.

7.3 Data related to emissions of ammonia and greenhouse gases

7.3.1 Data and coefficients

In table 17 a summary is given of the recommended collection of data and coefficients related to ammonia and greenhouse gases emissions, i.e. factors that determine the emissions from manure and N fertilizers, such as animal housing systems, manure storages, and manure/fertilizer application techniques.

For type of housing and manure storage systems, it is recommended to collect data on a farm level (farm survey) every 5 years. On the short term (< 2 years) information of the type of manure should be collected, i.e. systems based on solid and liquid manure, as type of manure has a large effect of ammonia, nitrous oxide, and methane emissions. On the intermediate term (2-5 years) it is recommended to collect systems according the IPCC guidelines, i.e.

- anaerobic lagoon,
- liquid system,
- daily spread,

- solid storage and drylot,
- pasture range and paddock, and
- other systems.

For the long-term (> 5 years) it is recommended to collect data to be used in Tier 2 or 3 approaches to calculate emissions, i.e. (see Task 3)

- information of the type of floor in housing systems (fully-slatted floor, partially slatted floor),
- type of housing (tied or loose),
- air treatment (mechanical ventilation, scrubbers or biofilters), and
- manure management (manure separation, anaerobic digester without or with added supplements).

For collecting data of manure application techniques, it is recommended to collect on short-term (< 2 years) data on application techniques not aiming at reducing ammonia emission (i.e. broadcast or no incorporation) and reduced ammonia application techniques (i.e. the other techniques). At the short term, estimates derived for the GAINS model can be used (i.e. partly based on consultation of member states) and start a survey to collect data on farms. For the long-term (> 5 years) it is recommended to collect the data of the following application techniques: Broadcast without incorporation,

- Broadcast + incorporation <2hrs,
- Broadcast - incorporation <1 day,
- Band spread,
- Deep injection, and
- Shallow injection

There are already good guidebooks, working groups and/or task forces in place to derive methods and coefficients to estimate ammonia and greenhouse gas emissions, i.e. the IPPC (IPPC guidelines), different taskforce under the UNECE, and the EMEP/EEA Guidebook. There is no further action needed to improve the methodologies and coefficients and EU member states are recommended to use Tier 2 or 3 approaches to estimate ammonia and greenhouse gases.

For the short-term, default emission factors on a national scale for ammonia and greenhouse gas emissions can be used according to IPCC Guidelines and the EMEP/EEA Guidebook. For the long-term, it recommended to derived country specific emission factors (Tier 3), e.g. using a TAN-based methodology for NH_3 emission (EEA/EMEP Guidebook).

Dairy cattle and other cattle are the largest source of methane produced during enteric fermentation). For the short term, it recommended to use at least IPPC Tier 1 methodology (tables with emission factors are included in IPCC Guidelines). For the long-term, it is recommended to develop Tier 2 approaches to estimate methane emission by enteric fermentations. For such approach, data are needed on weight, average weight gain per day, feeding situation, milk production per day, fat content milk, average amount of work performed per day, mean winter temperature, percentage of females that give birth in a year; wool growth; number of offspring; and feed digestibility. These date should be collected on a national scale and it is recommended to collect these data once (with updates if new insights to improve the emission factors are available).

For the methane production by enteric fermentation for the other categories, the default Tier 1 emission factors can be used (the tables with emission factors are included in the IPCC Guidelines).

7.3.2 Approaches and procedures

For type of housing and manure storage systems, it is recommended to collect data on a farm level (farm survey) every 5 years. On the short term (< 2 years) information of the type of manure should be collected, i.e. systems based on solid and liquid manure, as type of manure has a large effect of ammonia, nitrous oxide, and methane emissions. On the intermediate term (2-5 years) it is recommended to collect systems according the IPCC guidelines. For the long-term (> 5 years) it is recommended to collect data to be used in Tier 2 or 3 approaches to calculate emissions. It is recommended to include (and expand) the collection of types of housing and manure storage in the Survey on Agricultural Production Methods (SAPM) of FSS.

For collecting data of manure application techniques, it is recommended to collect on short-term (< 2 years) data on application techniques not aiming at reducing ammonia emission (i.e. broadcast or no incorporation) and reduced ammonia application techniques (i.e. the other techniques). At the short term, estimates derived for the GAINS model can be used (i.e. partly based on consultation of member states) and start a survey to collect data on farms. For the long-term (> 5 years) it is recommended to collect the data of more types of application techniques. It is recommended to include (and expand) the collection of types of housing and manure storage in SAPM.

There are already good guidebooks, working groups and/or task forces in place to derive methods and coefficients to estimate ammonia and greenhouse gas emissions, i.e. the IPPC (IPPC guidelines), different taskforce under the UNECE, and the EMEP/EEA Guidebook. There is no further action needed to improve the methodologies and coefficients and EU member states are recommended to use Tier 2 or 3 approaches to estimate ammonia and greenhouse gases.

7.4 Data related to N and P in harvested crop products

7.4.1 Data and coefficients

In table 18 a summary is given of the recommended collection of data and coefficients related to N and P in harvested crop products.

For calculation of the outputs data on the yields and N and P contents of the crop products are needed. For the yields, the current data collection system of Eurostat and member states can be used. The yields of major crops in a member states should be collected at the regional level, especially in large countries with regional differences in climatic conditions (and other factors affecting yields, such as soil type).

A methodology should be developed to estimate the grassland yields in different countries/regions in EU-27, taking the different management types into consideration (rough grazing, extensively managed, and intensively managed). This estimated may be based on empirical data (field experiments), results of crops models, expert estimates, and feed balances of dairy cattle (i.e. the feed N take can be estimated from the milk yield).

The N and P contents in the crop products in different regions in EU should be derived in a desk study, in which data are collected from measured N and P contents of different crops (e.g. in field experiments). Based on the collected data and modelling, the N and P contents of crops in EU 27 have to be estimated in dependency of the N and P inputs, as it is known the N and P contents are dependents of the N and P inputs, respectively.

7.4.2 Approaches and procedures

For the yields, the current data collection system of Eurostat and member states can be used. However, it is recommended to evaluate the procedures followed by the different countries (estimates by local experts or measured) and to verify if the estimated yields are the average yields.

It is recommended to install a working group (or start a project) with scientists, agronomists, and statisticians of different member states in order to develop a methodology to estimate the grassland yields in different countries/regions in EU-27, taking the different management types into consideration (rough grazing, extensively managed, and intensively managed).

It recommended to verify if the estimates and forecasts made by the Monitoring Agricultural ResourceS (MARS) Unit of JRC can be used as a source of yields or validation of yields.

It is recommended to carry out a project in order obtain the N and P contents in the crop products in different regions in EU and/or in dependency of the N and P inputs.

Table 16: Recommendations for collection of data and coefficients related to inputs of N and P

Type of input	Recommended collection of data and coefficients								Recommendation to improve data collection
	Primary data				Coefficents				
	Type	Scale of collection		Recommended source/method	Type	Scale of collection		Recommended source/method	
		Spatial	Temporal			Spatial	Temporal		
Manure	Number of livestock	Farm	Annual	Existing surveys; FSS, livestock registers	N and P excretion	Regional for dairy cattle (except countries with no clear regional differences) National for all other livestock categories	1X 3 yrs	Short-term: IPCC, GAINS, AP Nitrates Directive Long-term: methodology based on input-output balances of animals; to be developed	Install a working groups of scientists to set up i) a set of default N and P excretion rates for each livestock category and ii) a method to calculate N and P excretion on country or regional level, based on inputs and outputs at the animal level.
	Grazing system	Regional	1x 3 yrs	Survey on Agricultural Production Methods (SAPM)					Explore if SAPM contains the information to estimate the amount of N and P excreted during grazing
Fertilizer	N and P fertilizer consumption	National	Annual	Dissagregation of data on national scale to NUTS II level, based on crop requirements for N and P, fertilizer recommendation, application standards, expert knowledge. For ammonia emission calculation, following types have to be distinghuised: ammonium nitrate, calcium ammonium nitrate, anhydrous ammonia, ammonium phosphate, urea, urea-ammonium nitrate solution (UAN), and other N fertilizers is needed					* Improve estimates of national fertilizer consumption statistics (Eurostat - FAO - EFMA) * Install a working group of scientists, statisticians, and agronomistst to set up a methodology to dissagregate national fertilizer consumption. Local experts are asked to review (and adjust) the estimates of fertilizer application rates * Set up a small survey with the aim to validate and improve the methodology of downscaling national fertilizer consumption statistics
		Farm	1 x 3 yrs	Survey with aim to improve the downscaling methodology					
Other sources	Biological N fixation	National	Annual	The N fixed by leguminous crops, except clover, is estimated as the N uptake of the total crop. Statistics on crop yields can be used. N fixed by free living soil bacteria can be neglected	N fixation by clover	Regional	1 x 3 yr	Estimates by local experts with knowledge of the grasslands and management of grassland.	ask agronomists of member states to estimate the N fixed by clover
	Atmospheric N deposition	Regional	Annual	the EMEP data base					

Table 17: Recommendations for collection of data and coefficients related to factors affecting emissions of ammonia and greenhouse gases

Factor	Recommended collection of data and coefficients								Recommendation to improve data collection
	Primary data				Coefficents				
	Type	Scale of collection		Recommended source/method	Type	Scale of collection		Recommended source/method	
		Spatial	Temporal			Spatial	Temporal		
Manure management	Housing sytems	Farm	1x in 5 yrs	Short term: solid and liquid manure Intermediate term (IPCC guidelines): (i) anaerobic lagoon, (ii) liquid system, (iii) daily spread, (iv) solid storage and drylot, (v) pasture range and paddock, (vi) used fuel, and (vii) other systems. Long-term (Tier 2 approach): Housing with fully-slatted floor, partially slatted floor, tied, loose, mechanical ventilation, scrubbers or biofilters, manure separation, anaerobic digester (without/with added supplements)	Emission factor of NH3, N2O, NOx, N2 and CH4 emission from housing and manure storage	National	Once (update if new results are available)	Short-term: default emission factors for NH_3, N_2O, NOx, N2 and CH_4 according IPCC Guidelines and the EMEP/EEA Guidebook. Long-term: country specific emission factors (Tier 3) Long-term: TAN-based methodology for NH3 emission (EEA/EMEP Guidebook)	Continue current survey on manure storage in FSS and expand the number of systems in the survey in the future (in SAPM). Detailed on types of manure storage should only be collected if a Tier 2 or Tier 3 methodology is used, requiring detailed data.
	Manure storage system	Farm	1x in 5 yrs	Short term: solid and liquid manure Intermediate term (IPCC guidelines): (i) anaerobic lagoon, (ii) liquid system, (iii) daily spread, (iv) solid storage and drylot, (v) pasture range and paddock, (vi) used fuel, and (vii) other systems. Long-term (Tier 3 approach): Slurry stored in open tanks, Slurry stored in covered tanks, Slurry stored in lagoons, Slurry stored in underfloor pits, Manure stored in manure heaps, Manure composted, and Manure incinerated					
N application technique	Manure	farm	1x 3 yrs	Short-term: broadcast (no incorporation) and reduced ammonia application technique (i.e. the other techniques). Use estimates dervied for the GAINS model and start a survey to collect data on farms. Long-term: Broadcast - no incorporation, Broadcast - incorporation <2hrs, Broadcast - incorporation <1 day, Band spread, Deep injection, and Shallow injection	Emission factor of NH3, N2O from applied manure and fertilizer			Short-term: default emission factors for NH_3, N_2O according IPCC Guidelines and the EMEP/EEA Guidebook. Long-term: country specific emission factors (Tier 3) Long-term: TAN-based methodology for NH3 emission (EEA/EMEP Guidebook)	Manure application technique has a large effect on NH3 emission. Therefore, there is a strong need for good data about manure application techniques, starting with differentiation between broadcast spreading and reduced ammonia emission. On a short-term, data derived for the GAINS model can be used (on national level), but setting up systems for collecting data about manure application in farm surveys are needed. There also studies showing the manure application affects N2O emission.
	Fertilizer			No differentiation					
Livestock					CH4 from enteric fermentation	National	Once (update if new results are available)	Dairy cattle and other cattle: Short term: at least Tier 1 (tables included in IPCC Guidelines). Long-term: Tier 2: weight, average weight gain per day, feeding situation, milk production per day, fat content milk, average amount of work performed per day, mean winter temperature, percentage of females that give birth in a year; wool growth; number of offspring; and feed digestibility.. Tier 1 for the other categories (tables included in IPCC Guidelines).	

Table 18: Recommendations for collection of data and coefficients related to N and P in harvested crop products

<table>
<tr><th rowspan="4">Type of output</th><th colspan="8">Recommended collection of data and coefficients</th><th rowspan="4">Recommendation to improve data collection</th></tr>
<tr><th colspan="4">Primary data</th><th colspan="4">Coefficents</th></tr>
<tr><th rowspan="2">Type</th><th colspan="2">Scale of collection</th><th rowspan="2">Recommended source/method</th><th rowspan="2">Type</th><th colspan="2">Scale of collection</th><th rowspan="2">Recommended source/method</th></tr>
<tr><th>Spatial</th><th>Temporal</th><th>Spatial</th><th>Temporal</th></tr>
<tr><td>Total N removed by harvested arable crop</td><td>Yields</td><td rowspan="2">regional for major crops
national for other crops</td><td rowspan="2">Annual</td><td rowspan="2">Estimates by local expert. Current data-set</td><td>N content for each crop type</td><td rowspan="2">EU or region in EU (with different N inputs)</td><td rowspan="4">Once; 1 per 5 yr check if update is needed</td><td rowspan="4">It is recommended to carry out a desk study to obtain the N and P contents in the crop products in different regions in EU or in dependency of the N and P inputs.</td><td rowspan="4">It recommended to verify if the estimates and forecasts made by the Monitoring Agricultural ResourceS (MARS) Unit of JRC can be used as a source of yields or validation of yields.</td></tr>
<tr><td>Total P removed by harvested arable crop</td><td>Yields</td><td>N content for each crop type</td></tr>
<tr><td>Total N removed by harvested grassland (cut and grazed)</td><td>Yields</td><td rowspan="2">regional for countries with large differences in milk yields
national for other countries</td><td rowspan="2">Annual</td><td rowspan="2">A methodology should be developed to estimate the grassland yields in different countries/regions in EU-27, taking the different management types into consideration (rough grazing, extensively managed, and intensively managed).</td><td>N content grassland</td><td>Regional: dependent on N inputs and type of grassland</td></tr>
<tr><td>Total P removed by harvested grassland (cut and grazed)</td><td>Yields</td><td>P content grassland</td><td>Regional: dependent on N inputs and type of grassland</td></tr>
</table>

Annex: Specific recommendations for collection farm data related to gross nitrogen and phosphorus balances and ammonia and greenhouse gas emissions

This annex presents 6 tables with specific recommendations for collecting the farm data required to calculate gross nitrogen (N) and phosphorus (P) balances and ammonia (NH_3) and greenhouse gas (GHG) emissions. The 6 tables (Tables A1.1 to A1.6) include specifications for:

1. data related to inputs of N and P.
2. coefficients related to inputs of N and P.
3. data related to factors affecting emissions of ammonia and greenhouse gases.
4. coefficients related to factors affecting emissions of ammonia and greenhouse gases.
5. data related to N and P in harvested crop products.
6. coefficients related to N and P in harvested crop products

Table A1.1: Recommendations for collection of data related to inputs of N and P

Two scenarios are included. The minimum scenario is the scenario with collection of data which are at least needed for reporting for policies and AEI (e.g. Tier 1) and the optimum scenario is the scenario for collection of data in detailed approaches (e.g. Tier 2 and 3 methods).

Type of data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
		Number/amount				Spatial	Temporal	
Number of livestock	Minimum	dairy cattle	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Minimum	beef cattle	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Minimum	other cattle	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Minimum	sows, incl. piglets	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Minimum	fattening pigs	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Minimum	broilers	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Minimum	laying hens	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Minimum	other poultry	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Minimum	other	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	dairy cattle	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	beef cattle	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	young cattle	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS

Type of data	Scenario	Data specification Number/amount	Unit	Policy need	AEI need	Scale of collection		Source/method
						Spatial	Temporal	
Number of livestock	Optimum	calves	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	sows, incl. piglets	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	fattening pigs	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	boars	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	other pigs	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	broilers	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	laying hens	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	turkey	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	ducks	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	other poultry	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	sheep	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	goat	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Number of livestock	Optimum	horses	average number of live animals per farm	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Farm	Annual	Livestock registers, FSS
Grazing system	Minimum	dairy cattle	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM

Type of data	Scenario	Data specification Number/amount	Unit	Policy need	AEI need	Scale of collection		Source/method
						Spatial	Temporal	
Grazing system	Minimum	other cattle	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Minimum	other grazing livestock	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Optimum	dairy cattle	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Optimum	beef cattle	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Optimum	young cattle	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Optimum	calves	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Optimum	sheep	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Optimum	goat	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Optimum	horses	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM
Grazing system	Optimum	other grazing livestock	% of time spent outside	UNFCCC, WFD, ND, NECD	11.3, 10.2, 12, 13, 15, 16, 18, 19	Farm	1x 3 yrs	SAPM

Type of data	Scenario	Data specification Number/amount	Unit	Policy need	AEI need	Scale of collection		Source/method
						Spatial	Temporal	
N fertilizer consumption	Minimum	ammonium nitrate	kg N per country per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	National	Annual	Calculated on the basis of approved Protocols
N fertilizer consumption	Minimum	calcium ammonium nitrate	kg N per country per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	National	Annual	Calculated on the basis of approved Protocols
N fertilizer consumption	Minimum	anhydrous ammonia	kg N per country per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	National	Annual	Calculated on the basis of approved Protocols
N fertilizer consumption	Minimum	ammonium phosphate	kg N per country per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	National	Annual	Calculated on the basis of approved Protocols
N fertilizer consumption	Minimum	urea	kg N per country per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	National	Annual	Calculated on the basis of approved Protocols
N fertilizer consumption	Minimum	urea-ammonium nitrate solution (UAN)	kg N per country per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	National	Annual	Calculated on the basis of approved Protocols
N fertilizer consumption	Minimum	other N fertilizers	kg N per country per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	National	Annual	Calculated on the basis of approved Protocols
P fertilizer consumption	Minimum	P fertilizers (all types)	kg P per country per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	National	Annual	Calculated on the basis of approved Protocols
N fertilizer consumption	Optimum	calcium ammonium nitrate	kg N per ha per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	Farm	Annual	Farm survey

Type of data	Scenario	Data specification Number/amount	Unit	Policy need	AEI need	Scale of collection		Source/method
						Spatial	Temporal	
N fertilizer consumption	Optimum	anhydrous ammonia	kg N per ha per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	Farm	Annual	Farm survey
N fertilizer consumption	Optimum	ammonium phosphate	kg N per ha per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	Farm	Annual	Farm survey
N fertilizer consumption	Optimum	urea	kg N per ha per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	Farm	Annual	Farm survey
N fertilizer consumption	Optimum	urea-ammonium nitrate solution (UAN)	kg N per ha per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	Farm	Annual	Farm survey
N fertilizer consumption	Optimum	other N fertilizers	kg N per ha per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	Farm	Annual	Farm survey
P fertilizer consumption	Optimum	P fertilizers (all types)	kg P per ha per year	UNFCCC, WFD, ND, NECD	12, 13, 15, 16, 18, 19	Farm	Annual	Farm survey
Biological N fixation	Minimum/ optimum	clover	ha	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	Annual	FSS / Farm survey
Biological N fixation	Minimum/ optimum	peas	ha	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	Annual	FSS / Farm survey
Biological N fixation	Minimum/ optimum	beans	ha	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	Annual	FSS / Farm survey
Biological N fixation	Minimum/ optimum	soya bean	ha	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	Annual	FSS / Farm survey
Biological N fixation	Minimum/ optimum	lucerne	ha	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	Annual	FSS / Farm survey
Biological N fixation	Minimum/ optimum	lupins	ha	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	Annual	FSS / Farm survey
Atmospheric N deposition	Minimum/ optimum	dry deposition	kg N per ha per year	UNFCCC, WFD, ND, NECD	15, 18, 19	Regional	Annual	EMEP data base
Atmospheric N deposition	Minimum/ optimum	wet deposition	kg N per ha per year	UNFCCC, WFD, ND, NECD	15, 18, 19	Regional	Annual	EMEP data base

Table A1.2: Recommendations for collection of coefficients related to inputs of N and P

Two scenarios are included. The minimum scenario is the scenario with collection of data which are at least needed for reporting for policies and AEI (e.g. Tier 1) and the optimum scenario is the scenario for collection of data in detailed approaches (e.g. Tier 2 and 3 methods).

Type of coefficient	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of estimate		Source/method
						Spatial	Temporal	
N excretion	Minimum	dairy cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Minimum	beef cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Minimum	other cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Minimum	sows, incl. piglets	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Minimum	fattening pigs	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Minimum	broilers	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Minimum	laying hens	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Minimum	other poultry	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Minimum	other	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	dairy cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	beef cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	young cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols

Type of coefficient	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of estimate		Source/method
						Spatial	Temporal	
N excretion	Optimum	calves	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	sows, incl. piglets	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	fattening pigs	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	boars	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	other pigs	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	broilers	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	laying hens	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	turkey	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	ducks	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	other poultry	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	sheep	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	goat	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
N excretion	Optimum	horses	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Minimum	dairy cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols

Type of coefficient	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of estimate		Source/method
						Spatial	Temporal	
P excretion	Minimum	beef cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Minimum	other cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Minimum	sows, incl. piglets	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Minimum	fattening pigs	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Minimum	broilers	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Minimum	laying hens	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Minimum	other poultry	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Minimum	other	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	dairy cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	beef cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	young cattle	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	calves	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	sows, incl. piglets	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	fattening pigs	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols

Type of coefficient	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of estimate		Source/method
						Spatial	Temporal	
P excretion	Optimum	boars	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	other pigs	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	broilers	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	laying hens	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	turkey	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	ducks	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	other poultry	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	sheep	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	goat	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
P excretion	Optimum	horses	kg/animal/yr	UNFCCC, WFD, ND, NECD	10.2, 12, 13, 15, 16, 18, 19	National	1 x 3 yr	Calculated on the basis of approved Protocols
Biological N fixation	Minimum/ optimum	clover	kg N per ha leguminous crop per year	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols
Biological N fixation	Minimum/ optimum	peas	kg N per ha leguminous crop per year	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols
Biological N fixation	Minimum/ optimum	beans	kg N per ha leguminous crop per year	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols

Type of coefficient	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of estimate		Source/method
						Spatial	Temporal	
Biological N fixation	Minimum/ optimum	soya bean	kg N per ha leguminous crop per year	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols
Biological N fixation	Minimum/ optimum	lucerne	kg N per ha leguminous crop per year	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols
Biological N fixation	Minimum/ optimum	lupins	kg N per ha leguminous crop per year	UNFCCC, WFD, ND	4, 12, 13, 15, 16, 18, 19	Regional	1 x 3 yr	Calculated on the basis of approved Protocols

Table A1.3: Recommendations for collection of data related to factors affecting emissions of ammonia and greenhouse gases

Two scenarios are included. The minimum scenario is the scenario with collection of data which are at least needed for reporting for policies and AEI (e.g. Tier 1) and the optimum scenario is the scenario for collection of data in detailed approaches (e.g. Tier 2 and 3 methods).

Type of data	Scenario	Data specification	Required data	Unit / dimension	Policy need	AEI need	Scale of estimate		Source / method
							Spatial	Temporal	
Housing system	minimum	dairy, beef, and other cattle	Manure type; Solid/liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	minimum	dairy, beef, and other cattle	Manure type; Solid/liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	dairy, beef, and other cattle	tied housing with fully-slatted floor	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	dairy, beef, and other cattle	tied housing partially slatted floor	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	dairy, beef, and other cattle	loose housing with fully-slatted floor	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	dairy, beef, and other cattle	loose housing partially slatted floor	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	dairy, beef, and other cattle	tied housing with fully-slatted floor with scrubbers/biofilters	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	dairy, beef, and other cattle	tied housing partially slatted floor with scrubbers/biofilters	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	dairy, beef, and other cattle	loose housing with fully-slatted floor with scrubbers/biofilters	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	dairy, beef, and other cattle	loose housing partially slatted floor with	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM

Type of data	Scenario	Data specification	Required data	Unit / dimension	Policy need	AEI need	Scale of estimate		Source / method
							Spatial	Temporal	
			scrubbers/biofilters						
Manure storage system	optimum	dairy, beef, and other cattle	solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	dairy, beef, and other cattle	liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	dairy, beef, and other cattle	manure separation	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	dairy, beef, and other cattle	liquid with anaerobic digestion without supplements	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 24, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	dairy, beef, and other cattle	liquid with anaerobic digestion with supplements	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 24, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	minimum	pigs	Solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	minimum	pigs	Liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	minimum	pigs	Solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	minimum	pigs	Liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	pigs	Solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	pigs	Liquid with scrubbers/biofilters	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	pigs	solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	pigs	liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM

Type of data	Scenario	Data specification	Required data	Unit / dimension	Policy need	AEI need	Scale of estimate		Source / method
							Spatial	Temporal	
Manure storage system	optimum	pigs	manure separation	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	pigs	liquid with anaerobic digestion without supplements	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 24, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	pigs	liquid with anaerobic digestion with supplements	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 24, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	minimum	poultry	Solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	minimum	poultry	Liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	minimum	poultry	Solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	minimum	poultry	Liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	poultry	Battery cages	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Housing system	optimum	poultry	Battery cages with drying	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	poultry	Free range	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	poultry	Aviary house	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	poultry	Other	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	poultry	Solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	optimum	poultry	Liquid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM

Type of data	Scenario	Data specification	Required data	Unit / dimension	Policy need	AEI need	Scale of estimate		Source / method
							Spatial	Temporal	
Housing system	minimum	other	Solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure storage system	minimum	other	Solid	Dimension less	UNFCCC, ND, NECD	11.3, 12, 16, 18, 19, 28	Farm	1 x 5 yr	FSS; SAPM
Manure application technique	minimum	grassland and arable land	surface spreading	Dimension less	UNFCCC, ND, NECD	11.2, 12, 15, 16, 18, 19	Farm	1 x 3 yr	FSS; SAPM
Manure application technique	minimum	grassland and arable land	reduced ammonia application	Dimension less	UNFCCC, ND, NECD	11.2, 12, 15, 16, 18, 19	Farm	1 x 3 yr	FSS; SAPM
Manure application technique	optimum	grassland and arable land	Broadcast - no incorporation	Dimension less	UNFCCC, ND, NECD	11.2, 12, 15, 16, 18, 19	Farm	1 x 3 yr	FSS; SAPM
Manure application technique	optimum	arable land	Broadcast - incorporation <2hrs	Dimension less	UNFCCC, ND, NECD	11.2, 12, 15, 16, 18, 19	Farm	1 x 3 yr	FSS; SAPM
Manure application technique	optimum	arable land	Broadcast - incorporation <1 day	Dimension less	UNFCCC, ND, NECD	11.2, 12, 15, 16, 18, 19	Farm	1 x 3 yr	FSS; SAPM
Manure application technique	optimum	grassland and arable land	Band spread	Dimension less	UNFCCC, ND, NECD	11.2, 12, 15, 16, 18, 19	Farm	1 x 3 yr	FSS; SAPM
Manure application technique	optimum	grassland and arable land	Deep injection	Dimension less	UNFCCC, ND, NECD	11.2, 12, 15, 16, 18, 19	Farm	1 x 3 yr	FSS; SAPM
Manure application technique	optimum	grassland and arable land	Shallow injection	Dimension less	UNFCCC, ND, NECD	11.2, 12, 15, 16, 18, 19	Farm	1 x 3 yr	FSS; SAPM

Table A1.4: Recommendations for collection of coefficients related to factors affecting emissions of ammonia and greenhouse gases

Two scenarios are included. The minimum scenario is the scenario with collection of data which are at least needed for reporting for policies and AEI (e.g. Tier 1) and the optimum scenario is the scenario for collection of data in detailed approaches (e.g. Tier 2 and 3 methods).

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Housing system	minimum	dairy, beef, and other cattle	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Housing system	minimum	dairy, beef, and other cattle	Liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	minimum	dairy, beef, and other cattle	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	minimum	dairy, beef, and other cattle	Liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	tied housing with fully-slatted floor	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	tied housing partially slatted floor	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	loose housing with fully-slatted floor	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	loose housing partially slatted floor	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	tied housing with fully-slatted floor with scrubbers/biofilters	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Housing system	optimum	dairy, beef, and other cattle	tied housing partially slatted floor with scrubbers/biofilters	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	loose housing with fully-slatted floor with scrubbers/biofilters	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	loose housing partially slatted floor with scrubbers/biofilters	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	manure separation	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	liquid with anaerobic digestion without supplements	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	liquid with anaerobic digestion with supplements	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	minimum	pigs	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Housing system	minimum	pigs	Liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Manure storage system	minimum	pigs	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	minimum	pigs	Liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	pigs	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	pigs	Liquid with scrubbers/biofilters	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	pigs	solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	pigs	liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	pigs	manure separation	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	pigs	liquid with anaerobic digestion without supplements	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	pigs	liquid with anaerobic digestion with supplements	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	minimum	poultry	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Housing system	minimum	poultry	Liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	minimum	poultry	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	minimum	poultry	Liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	poultry	Battery cages	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Housing system	optimum	poultry	Battery cages with drying	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Free range	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Aviary house	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Other	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Liquid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Housing system	minimum	other	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure storage system	minimum	other	Solid	% of N excreted	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure application technique	minimum	grassland and arable land	surface spreading	% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure application technique	minimum	grassland and arable land	reduced ammonia application	% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Manure application technique	optimum	grassland and arable land	Broadcast - no incorporation	% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure application technique	optimum	arable land	Broadcast - incorporation <2hrs	% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure application technique	optimum	arable land	Broadcast - incorporation <1 day	% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure application technique	optimum	grassland and arable land	Band spread	% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure application technique	optimum	grassland and arable land	Deep injection	% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook
Manure application technique	optimum	grassland and arable land	Shallow injection	% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
N fertilizer	Minimum/ optimum	ammonium nitrate		% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
N fertilizer consumption	Minimum/ optimum	calcium ammonium nitrate		% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
N fertilizer consumption	Minimum/ optimum	anhydrous ammonia		% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
N fertilizer consumption	Minimum/ optimum	ammonium phosphate		% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
N fertilizer consumption	Minimum/ optimum	urea		% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
N fertilizer consumption	Minimum/ optimum	urea-ammonium nitrate solution (UAN)		% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
N fertilizer consumption	Minimum/ optimum	other N fertilizers		% of N applied	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Grazing	Minimum/ optimum	grazing livestock		% of N excreted during grazing	ammonia emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	EEA/EMEP Guidebook
Housing system	minimum	dairy, beef, and other cattle	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Housing system	minimum	dairy, beef, and other cattle	Liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Manure storage system	minimum	dairy, beef, and other cattle	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Manure storage system	minimum	dairy, beef, and other cattle	Liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	dairy, beef, and other cattle	tied housing with fully-slatted floor	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	dairy, beef, and other cattle	tied housing partially slatted floor	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	dairy, beef, and other cattle	loose housing with fully-slatted floor	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	dairy, beef, and other cattle	loose housing partially slatted floor	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	dairy, beef, and other cattle	tied housing with fully-slatted floor with scrubbers/biofilters	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	dairy, beef, and other cattle	tied housing partially slatted floor with scrubbers/biofilters	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	dairy, beef, and other cattle	loose housing with fully-slatted floor with scrubbers/biofilters	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	dairy, beef, and other cattle	loose housing partially slatted floor with scrubbers/biofilters	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Manure storage system	optimum	dairy, beef, and other cattle	solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	dairy, beef, and other cattle	liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	dairy, beef, and other cattle	manure separation	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	dairy, beef, and other cattle	liquid with anaerobic digestion without supplements	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	dairy, beef, and other cattle	liquid with anaerobic digestion with supplements	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	minimum	pigs	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Housing system	minimum	pigs	Liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Manure storage system	minimum	pigs	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Manure storage system	minimum	pigs	Liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Housing system	optimum	pigs	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Housing system	optimum	pigs	Liquid with scrubbers/biofilters	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	pigs	solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	pigs	liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	pigs	manure separation	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	pigs	liquid with anaerobic digestion without supplements	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	pigs	liquid with anaerobic digestion with supplements	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	minimum	poultry	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Housing system	minimum	poultry	Liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Manure storage system	minimum	poultry	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Manure storage system	minimum	poultry	Liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Housing system	optimum	poultry	Battery cages	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	optimum	poultry	Battery cages with drying	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	poultry	Free range	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	poultry	Aviary house	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	poultry	Other	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	poultry	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure storage system	optimum	poultry	Liquid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Housing system	minimum	other	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Manure storage system	minimum	other	Solid	% of N excreted	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Manure application technique	minimum	grassland and arable land	surface spreading	% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Manure application technique	minimum	grassland and arable land	reduced ammonia application	% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Manure application technique	optimum	grassland and arable land	Broadcast - no incorporation	% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure application technique	optimum	arable land	Broadcast - incorporation <2hrs	% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure application technique	optimum	arable land	Broadcast - incorporation <1 day	% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure application technique	optimum	grassland and arable land	Band spread	% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure application technique	optimum	grassland and arable land	Deep injection	% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
Manure application technique	optimum	grassland and arable land	Shallow injection	% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology
N fertilizer	Minimum/ optimum	ammonium nitrate		% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
N fertilizer consumption	Minimum/ optimum	calcium ammonium nitrate		% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
N fertilizer consumption	Minimum/ optimum	anhydrous ammonia		% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
N fertilizer consumption	Minimum/ optimum	ammonium phosphate		% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
N fertilizer consumption	Minimum/ optimum	urea		% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
N fertilizer consumption	Minimum/ optimum	urea-ammonium nitrate solution (UAN)		% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
N fertilizer consumption	Minimum/ optimum	other N fertilizers		% of N applied	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Grazing		grazing livestock		% of N excreted during grazing	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Crop residues				% in crop residue	nitrous oxide emission factor	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology
Housing system	minimum	dairy, beef, and other cattle	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	minimum	dairy, beef, and other cattle	Liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	minimum	dairy, beef, and other cattle	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Manure storage system	minimum	dairy, beef, and other cattle	Liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	tied housing with fully-slatted floor	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	tied housing partially slatted floor	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	loose housing with fully-slatted floor	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	loose housing partially slatted floor	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	tied housing with fully-slatted floor with scrubbers/biofilters	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	tied housing partially slatted floor with scrubbers/biofilters	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	dairy, beef, and other cattle	loose housing with fully-slatted floor with scrubbers/biofilters	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Housing system	optimum	dairy, beef, and other cattle	loose housing partially slatted floor with scrubbers/biofilters	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	manure separation	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	liquid with anaerobic digestion without supplements	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	dairy, beef, and other cattle	liquid with anaerobic digestion with supplements	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	minimum	pigs	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	minimum	pigs	Liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Manure storage system	minimum	pigs	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	minimum	pigs	Liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	pigs	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	pigs	Liquid with scrubbers/biofilters	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	pigs	solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	pigs	liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	pigs	manure separation	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	pigs	liquid with anaerobic digestion without supplements	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Manure storage system	optimum	pigs	liquid with anaerobic digestion with supplements	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	minimum	poultry	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	minimum	poultry	Liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	minimum	poultry	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	minimum	poultry	Liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	poultry	Battery cages	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	optimum	poultry	Battery cages with drying	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Free range	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Manure storage system	optimum	poultry	Aviary house	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Other	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	optimum	poultry	Liquid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	National	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	minimum	other	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Manure storage system	minimum	other	Solid	% of N excreted	total denitrification loss	UNFCCC, ND, NECD	15, 16, 18, 19	No; default	1 x 5 yr	IPPC methodology/ EEA/EMEP Guidebook
Housing system	minimum	dairy, beef, and other cattle	Enteric fermentation	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Manure storage system	minimum	dairy, beef, and other cattle	Solid	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Manure storage system	minimum	dairy, beef, and other cattle	Liquid	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology

Type of data	Scenario	First data specification	Second data specification	Unit / dimension	Required coefficient	Policy need	AEI need	Scale of estimate		Source/method
								Spatial	Temporal	
Housing system	minimum	pigs	Enteric fermentation	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Manure storage system	minimum	pigs	Solid	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Manure storage system	minimum	pigs	Liquid	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Manure storage system	minimum	poultry	Solid	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Manure storage system	minimum	poultry	Liquid	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Housing system	minimum	other	Enteric fermentation	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Manure storage system	minimum	other	Solid	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology
Manure storage system	minimum	other	Liquid	kg CH4/ animal/yr	methane emission factor	UNFCCC	19	No; default	1 x 5 yr	IPCC methodology

Table A1.5: Recommendations for collection of data related to N and P in harvested crop products

Two scenarios are included. The minimum scenario is the scenario with collection of data which are at least needed for reporting for policies and AEI (e.g. Tier 1) and the optimum scenario is the scenario for collection of data in detailed approaches (e.g. Tier 2 and 3 methods).

Type of data	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Wheat	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Rye	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Barley	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Spring barley	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Oats	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Grain maize	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Sorghum	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Triticale	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Rice	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS

Type of data	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Other cereals	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Peas	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Beans	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Potatoes	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Sugar beet	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Fodder beet	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Other root crops	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Rape	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Sunflower seed	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Soya bean	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Other oil seeds	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS

Type of data	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Industrial crops (flax, hemp, cotton, tobacco, hops)	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Officinal herbs, aromatic plants	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Silage maize	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Clover and mixtures	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Lucerne	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Temporary grassland	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Permanent grassland	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Common pasture, heathland, rough grazings	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Fruit trees	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS

Type of data	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Olives	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Vineyards	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Other permanent crops	Optimum	area	ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	FSS
Wheat	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Rye	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Barley	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Spring barley	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Oats	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys

Type of data	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Grain maize	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Sorghum	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Triticale	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Rice	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Other cereals	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Peas	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Beans	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Potatoes	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys

Type of data	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Sugar beet	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Fodder beet	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Other root crops	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Rape	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Sunflower seed	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Soya bean	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Other oil seeds	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Industrial crops (flax, hemp, cotton, tobacco, hops)	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys

Type of data	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Officinal herbs, aromatic plants	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Silage maize	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Clover and mixtures	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Lucerne	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Temporary grassland	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	Estimated on the basis of approved Protocol
Permanent grassland	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	Estimated on the basis of approved Protocol
Common pasture, heathland, rough grazings	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	Estimated on the basis of approved Protocol
Fruit trees	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys

Type of data	Scenario	Data specification	Unit / dimension	Policy need	AEI need	Scale of collection		Source/metho d
Crop type						Spatial	Temporal	
Olives	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Vineyards	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys
Other permanent crops	Optimum	harvested yield	kg product per ha	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Farm	Annual	MARS, FADN, crop yield surveys

Table A1.6: Recommendations for collection of coefficients related to N and P in harvested crop products

Two scenarios are included. The minimum scenario is the scenario with collection of data which are at least needed for reporting for policies and AEI (e.g. Tier 1) and the optimum scenario is the scenario for collection of data in detailed approaches (e.g. Tier 2 and 3 methods).

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Wheat	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Rye	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Barley	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Spring barley	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Oats	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Grain maize	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Sorghum	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Triticale	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Rice	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Other cereals	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Peas	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Beans	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Potatoes	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Sugar beet	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Fodder beet	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Other root crops	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Rape	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Sunflower seed	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Soya bean	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Other oil seeds	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Industrial crops (flax, hemp, cotton, tobacco, hops)	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Officinal herbs, aromatic plants	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Silage maize	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Clover and mixtures	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Lucerne	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Temporary grassland	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Regional	1x 5 yr	Results desk study
Permanent grassland	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Regional	1x 5 yr	Results desk study
Common pasture, heathland, rough grazings	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Regional	1x 5 yr	Results desk study
Fruit trees	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Olives	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Vineyards	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Other permanent crops	Optimum	N content	kg N per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Wheat	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Rye	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Barley	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Spring barley	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Oats	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Grain maize	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Sorghum	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Triticale	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Rice	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Other cereals	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Peas	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Beans	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Potatoes	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Sugar beet	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Fodder beet	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Other root crops	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Rape	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Sunflower seed	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Soya bean	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Other oil seeds	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Industrial crops (flax, hemp, cotton, tobacco, hops)	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Officinal herbs, aromatic plants	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Silage maize	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Clover and mixtures	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Lucerne	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Temporary grassland	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Regional	1x 5 yr	Results desk study
Permanent grassland	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Regional	1x 5 yr	Results desk study
Common pasture, heathland, rough grazings	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	Regional	1x 5 yr	Results desk study
Fruit trees	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

Type of Data	Scenario	Data specification	Unit	Policy need	AEI need	Scale of collection		Source/method
Crop type						Spatial	Temporal	
Olives	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Vineyards	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study
Other permanent crops	Optimum	P content	kg P per kg harvested product	UNFCCC, LULUCF, ND, NECD, FDSUP, RDP	5, 6, 7, 8, 9, 10.1, 10.2, 11.1, 15, 16, 26	EU	1 x 5 yr	Results desk study

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