FARM DATA NEEDED FOR AGRI-ENVIRONMENTAL REPORTING

Technical document summarizing the findings of the DireDate project for the Final Seminar in Luxembourg on 28 March 2011[1]

Annex 3. Towards a common and harmonized data collection for AEIs related to manure and fertilizer use.

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Annex 3. Towards a common and harmonized data collection for AEIs related to manure and fertilizer use

This annex presents data requirements and recommendations for each step in the common and harmonized data collection – processing – reporting chain for AEIs related to manure and fertilizers, as discussed in Chapter 6. The various steps are indicated in Figure A.3.1.

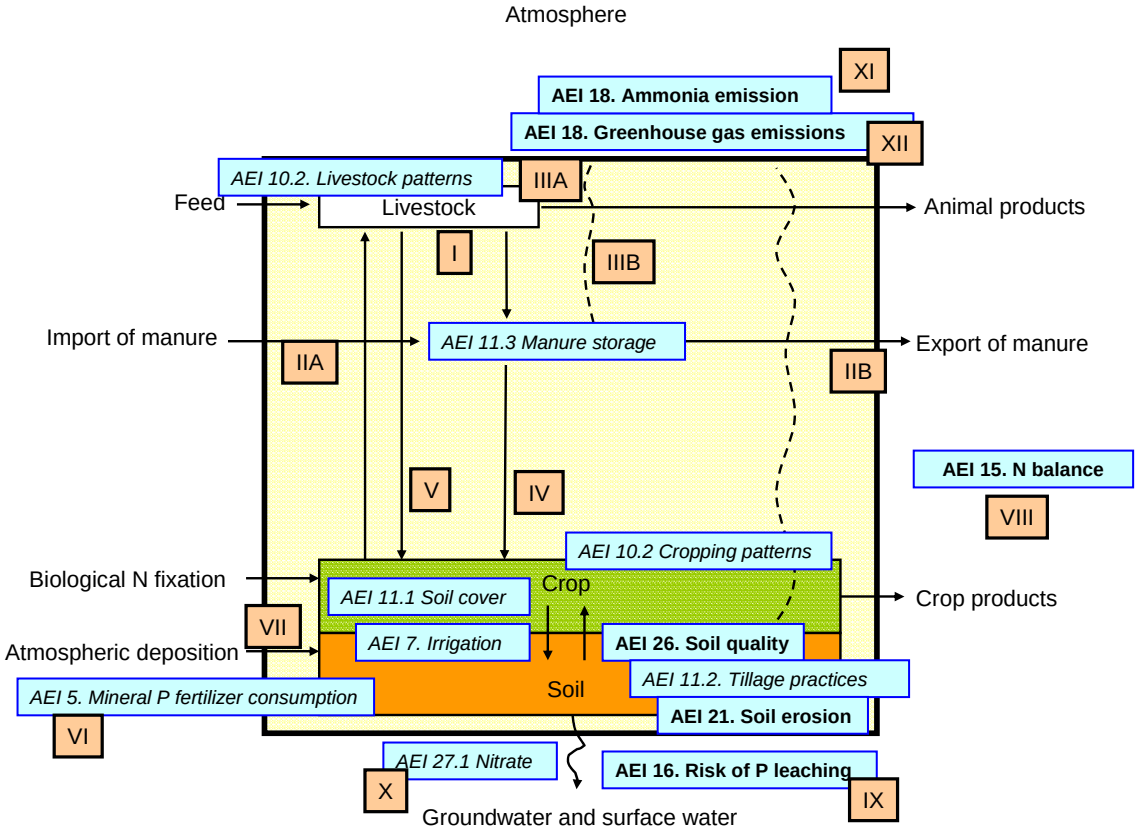

Figure A.3.1. Scheme with calculations steps for data collection and processing to estimate the AEIs related to emissions of N and P balances and emissions of ammonia and greenhouse gases. The steps (Roman numbers in boxes) are explained in the text.

Step 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).

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 specific 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.
- 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 a uniform approach to calculate N and P excretion in the EU-27 countries. The methodologies to calculate N and P excretion, using input-output balances and several data sources, are available.
- 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). It is recommended that these countries use the calculated N and P excretion rates for the AEIs.
- 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 (TAN = Total ammoniacal nitrogen) method to calculate ammonia emissions, the TAN excretion has to be estimated. This can be done using standard values for TAN or by calculation using the composition of feed.
- For calculation of the C excretion, the IPCC methodology can be used.

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.

Recommendations:

- The export/import of manure has to be considered on a region scale (i.e. transport between regions within a country) and 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 is 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.

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.*

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,

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 the 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 (%).

- 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, the mineralization and immobilization of N during the storage of manure have to be calculated. It is recommended to follow EEA/EMEP Guidebook.

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

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.

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.

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.

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.

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.*

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.

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 or FAO) 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 the N and P balance should be derived on a regional level and an agricultural sector basis, 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 (disaggregation) of 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. The data collected in such a survey 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.
- 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.

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

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 recommended 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 derived 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.
- 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.
- 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.

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.

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
- It 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.

***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.

Recommendations:
Estimation of the vulnerability of agricultural land to P leaching and run-off to the aquatic environment requires a large amount of spatially and temporally explicit data. The

following (combination of data) are helpful to improve the estimate of the risk of P leaching in combination with the P surplus:

- Phosphorus status of soils, soil test P values, P saturation index and P sorption capacity. *Potential data source – 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.

***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.

Recommendations:

- Use monitoring for Water Framework Directive and Nitrates Directive EEA, as published by EEA in the WISE data base (Water Information System for Europe). There are three datasets publicly available via WISE. 'Waterbase – Lakes', 'Waterbase – Rivers' and 'Waterbase – Groundwater'.

***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**). 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.

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.

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.