Methodological studies in the field of Agro-Environmental Indicators.
Lot 1 excretion coefficients

Analyses of the coherence, differences and best practices

Task 3

Oene Oenema[1*]), Leon Sebek[2]), Hans Kros[1]), Jan Peter Lesschen[1]), Marinus van Krimpen[2]), Paul Bikker[2]), Ad van Vuuren[2]) & Gerard Velthof[1])

1) Wageningen University, Alterra, P.O. Box 47, NL-6700 AA Wageningen, The Netherlands

2) Wageningen University, Livestock Research, P.O. Box 65, 8200 AB Lelystad, The Netherlands

*) Corresponding author oene.oenema@wur.nl

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Executive Summary

Introduction

The general objective of the study "*Nitrogen and phosphorus excretion coefficients for livestock of the Methodological studies in the field of Agro-Environmental Indicators*" *(2012/S 87-142068)* is "to bring clarity into the issue of excretion coefficients so that a recommendation on a single, common methodology to calculate N and P excretion coefficients can be identified. The study consists of seven Tasks, each with specific objectives.

The task reported here (*Task 3 "Analyses of the coherence, differences and best practices" ,)* builds further on the analyses carried out in Tasks 1 and 2. It reports on the coherence and differences in the methodologies for estimating N and P excretion coefficients in Member States and identifies best practices. The main aims are:

- To analyse the coherence and differences of the methodologies used to estimate N and P excretions;
- To identify the main components (building blocks) of the methodologies
- To analyse the comparability of the reported N and P flows, balances and emissions, both within countries and between countries, when using different methodologies for calculating excretion coefficients;
- To identify best practices for calculating N and P excretion coefficients.

Below, a general overview is presented of the project, based on manuscripts submitted to the RAMIRAN Conference hold in Versailles, France, June 3-5, 2013, and to the EAAP Conference hold in Nantes, France, August 26-30, 2013.

Background

Livestock production systems exert various influences on the environment. The influences greatly depend on the livestock production system itself, the management and the environmental conditions. Much of the influence on the environment occurs via feed production, manure utilization and through emissions association with animal production.

Globally, approximately 70% of the agriculturally used land area is for the production of feed. However, only 40 to 60% of the carbon (C) and 10 to 50% of the nitrogen (N) and phosphorus (P) in feed are retained by the animals in meat, milk and egg, while the remainder is excreted in urine and faces. As such, livestock excreta is a large source of C, N, P and other (micro) nutrients, to be used for increasing soil fertility and crop yields. Globally, livestock excretes about 100 Tg) N per year (range 70-140 Tg, but only 20-40% of this amount is recovered and applied to crop land. Most of the remainder is dissipated into the environment. The amounts of P and potassium (K) in livestock manure are roughly 1.5 and 3 times the current amounts of P and K in mineral fertilizers, respectively. The total amount of N excreted by livestock in the 27 Member States of the European Union (EU-27) is in the range of 10-11 Tg and the total amount of P excreted ranges between 1.5 and 2.5 Tg per year. These amounts are in the same order of magnitude as the amounts of N and P in fertilizers in EU-27.

However, the estimated N and P excretions are uncertain. Member States in the EU-27 estimate N and P excretions for the purpose of the estimation of N and P inputs to agricultural land, (gross) N and P balances, ammonia emissions, and greenhouse gas emissions. Currently, consistency is lacking (i) at national level for excretion coefficients used for different policies, and (ii) at EU-27 level, for excretion coefficients used by Member States. These inconsistencies arise from the use of different methodologies and the use of different data (quality). In response, the European Commission initiated a study by the end of 2012 with the general objective 'to bring clarity into the issue of excretion coefficients so that a recommendation on a single, common methodology to calculate N and P excretion coefficients can be identified'. The specific objectives of the study are:

- To create an overview of the different methodologies used in Europe to calculate excretion coefficients for N and P, and analyse their strengths and weaknesses;
- To set up a database with the excretion coefficients presently used in different reporting systems and describe the main factors that cause distortion within a country and across the EU;
- To provide guidelines for a coherent methodology, consistent with IPCC and CLTRP guidelines, for calculating N and P excretion coefficients, and taking into consideration the animal balance and taking into account different methodologies identifies under the first bullet point;
- To create default P-excretion coefficients that can be used by the countries who do not have yet own factors calculated;
- To identify the main components of the calculations of excretion coefficients and the data requirements for these components in such a detail that they allow introducing them in data collection systems.

Materials and Methods

Reports from all Member States of the EU-27 and other countries with information about N and P excretion coefficients, manure production volumes, N and P contents of manure and gaseous N losses from manure storages were reviewed. For each of the reports, the methodology applied, the N and P coefficients per animal category, and the spatial scale were recorded. In addition, assessments were made of the completeness, strength and weaknesses of the methodology, the data and information used, and the quality control procedures. The following reports have been reviewed:

  - General scientific literature about N and P excretion coefficients;
  - OECD/Eurostat reports on Gross Nitrogen and Phosphorus Balances;
  - Member States' Action Programmes under the EU Nitrates Directive;
  - Member States' inventories of greenhouse gas emissions under the UNFCCC

- Member States' inventories of ammonia emissions under the UNECE-CLRTAP and EU-NEC;
- The FAO Life Cycle Analysis (LCA) of livestock production;
- The IIASA methodology applied in the model RAINS/GAINS
- The methodology applied in the GGELS project;

Results of the inventory were stored in a database with N and P excretion coefficients per animal category and Member States. Next, systematic and in-depth analyses were made of selected countries, and the strength and weaknesses of the methodologies, their data requirements, accuracy and practical feasibility were assessed. Based on the aforementioned analyses, draft guidelines for common approaches and methodologies will be developed and documented with underlying arguments in a draft report, to be discussed during the second half of 2013 in workshops.

Results and Discussion

General observations

Most of the pertinent policies require the reporting of gross N and P excretion (ex animal) per animal category. However, some policies (e.g. Nitrates Directive, Gross Nitrogen Balances, national policies on fertilization planning) require the reporting of N excretion corrected for gaseous N losses during storage (ex storage). The latter is also called 'manure N and P production', which for P is assumed to be equal to P excretion. Generally, three pertinent scales are distinguished, i.e., farm level, regional level (which can be an administrative unit, i.e., district, county, NUTS 2, or a catchment) and national scale, depending on the purpose of the accounting. In animal sciences research, the individual animals are often object of study, also to find out (genetic) differences between animals and their response to management factors, including animal diets. However, the latter is beyond the scope of this study.

Roughly three methodologies for the estimation of N and P excretion and production are applied by Member States, i.e., (i) default coefficients, based on literature studies and expert judgement, (ii) input-output balance calculations, and (iii) measurements of the volume and N and P contents of manure produced. The most common method is the input-output balance calculation, which assumes that the amount of N and P excreted in faeces and urine is equal to the total amount of feed N and P consumed minus the N and P retained in marketed products (milk, meat, eggs, live weight gain), respectively. Hence, excretion = intake – retention. All methodologies allow in principle for making adjustment according to the length of the production cycle and for non-use of the stock accommodation, to provide an annual output factor per "animal place". The latter is necessary to allow for non-productive time needed for cleaning and re-stocking the housings.

Input-output balances require the estimation of the intake of N and P via feed, and of the N retention in animal products. The amounts of N and P consumed by the animal depends on the amount of feed digested by the animal, and the N and P contents of that feed. Total feed intake depends on the maintenance cost and production level of the animal (e.g., growth rate, milk and egg production), and the feeding value and digestibility of the feed. Data on the annual N and P retention in meat, egg, milk, or wool produced is usually derived from production statistics and scientific reports about the N and P contents in animal products.

Review of policy reports

For reporting emissions of greenhouse gases from agriculture to the UNFCCC, detailed IPCC guidelines are available, which include recommendations for the calculation of N excretion coefficients. The Guidelines contain recommendations at three levels of detail (Tier levels). The Tier 1 approach is the most simple method and includes default estimates of excretion. The Tier 2 and 3 approaches are more detailed; Tier 3 include country specific methodologies and estimates. Our inventory indicates that 4 Member States use default coefficients (Tier 1) and 21 use country specific methodologies (Tier 3), while the method was not clearly reported for 2 Member States.

For reporting emissions of ammonia from agriculture to the UNECE-CLRTAP and EU-NEC, detailed guidelines are provided by the EMEP/EEA Air Pollutant Emission Inventory Guidebook, which include recommendations for the calculation of N excretion coefficients, at two Tier levels. Our inventory indicates that 18 Member States use default N excretion coefficients and 9 use country specific methodologies. The OECD/Eurostat Nitrogen and Phosphorus Balance Handbooks provide also guidance to the calculations of N and P excretion coefficients. When N and P excretion coefficients are not compliant with the guidelines in the OECD/Eurostat Handbook, OECD/Eurostat take estimates from pertinent country reports to the UNFCCC.
Our review indicates that the N excretion coefficients per animal category may vary by up to a factor of 2 between Member States. The same holds for P excretion. Interestingly, estimated N excretion coefficients per animal category may vary up to 20% for a Member State, depending on the (policy) reports.

Country-specific estimation of N and P excretion coefficients

Country-specific input-output balances require information about N and P retention in animal products and about the intake and composition of feed per animal category. Table 1 list the mean protein N content of pig diets for selected countries; N contents are relatively low in pig diets in The Netherlands and rather high in Ireland and United Kingdom (UK). In Germany, standard and low N diets are distinguished for fattening pigs, adjusted to growth rates of 700 or 800 g/d, resulting in ranges of N.

Table 1. Mean N contents of pig diets per pig category (g/kg) in selected countries.

Category	Ireland	Italy	Germany	Netherlands	UK
Starter diet weanling pigs	35.2	29.1	29.6	27.0	35.2
Grower diet weanling pigs (12-26 kg)	32.0		28.0	27.9	32.0

Starter diet finishing pigs (26–30 kg)	32.0		28.8 – 29.6	27.1	32.0
Grower diet finishing pigs (30–70 kg)	29.6	24.5	26.4 – 28.0	26.2	29.6
Finisher diet (70–114 kg)	27.2		22.4 – 23.2	23.6	27.2
Rearing sow diet (26–125 kg)	25.6	?	23.2 – 28.0	24.5	25.6
Standard sow diet	?		27.2	23.8	?
Lactating sow diet	27.2	24.0	28.0	24.5	27.2
Gestating sow diet	20.0		23.2	20.4	20.0

Table 2 provide a brief overview of the mean N retention by pigs per kg live weight gain for some selected countries. In Germany, the N content of all pig categories is fixed at 25.6 g/kg. For piglets and growing finishing pigs, this value is generally high compared to the values used in other countries. For breeding sows, the 25.6 g/kg is also used in Ireland and the UK. Only higher values are used for 4-week old weaned piglets (30.4 g/kg) and boars (27.4 g/kg) in Ireland and the UK. For the category of growing finishing pigs, comparable values (24.8 – 25.0 g/kg) are used in Ireland, the Netherlands and UK. In Italy, a rather low value (24.0 g/kg) is used for this type of pigs. This low value may be related to a relatively high fat content of fattening pigs, because of the high slaughter weight (163 kg). The N content of Italian piglets, sows and boars have not been reported.

Similar or larger variations have been observed for other animal categories, especially for grazing animals, such as dairy cows. For grazing animals, the N content of the feed highly depends on the N fertilization level of the grassland, the inclusion of leguminous species in the sward, and the fractions of silage maize and concentrates in the diet.

Table 2. Mean N contents of pigs per category (g/kg liveweight) for selected countries.

Category	Weight, kg	Age	Ireland	Italy	Germany	Netherlands	UK
Dead piglet	1.3	0 days	?	?	25.6	18.7	?
Culled piglet	2.8	1 – 28 days	?	?	25.6	23.1	?
Culled piglet	9.0	29 – 42 days	?	?	25.6	24.3	?
Weaned piglet	7.0	4 weeks	30.4	?	25.6	?	30.4
Weaned piglet	11.0	6 weeks	25.0	?	25.6	24.4	25.0
Culled piglet	12.0	7 weeks	?	?	25.6	24.5	?
Growing pig	26	10 weeks	25.0	24.0	25.6	24.8	25.0
Finishing pig	114	26 weeks	25.0	24.0	25.6	25.0	25.0
Rearing sow	125	7 months	22.0	?	25.6	24.9	22.0
Rearing sow	140	First mating	22.0	?	25.6	24.9	22.0
Rearing boar	135	7 months	27.4	?	25.6	24.9	27.4
Boar	325	2 years	27.4	?	25.6	25.0	27.4
Breeding sow	220	At weaning	25.6	?	25.6	25.0	25.6
Sow at slaughter	220	At weaning	25.6	?	25.6	25.0	25.6

Towards a common approach

The data collection – processing – reporting systems for N and P excretion by livestock in EU-27 are diverse and often complex, in part because of differences between Member States in livestock production systems and in historical and cultural backgrounds. A common methodology would allow for a common and transparent estimation of N and P excretion in EU-27, and hence for a common basis for the estimation of manure N and P production, N and P balances, and ammonia and greenhouse gas emissions. Figure 1 shows the main building blocks of such common methodology, based on the input-output balance calculations. The input-output balance is a flexible method and provides also insight in the possibilities for management interventions to decrease N and P excretions.

In some countries, dairy farmers use a certified modeling tool to calculate farm specific N and P excretion of cattle, using farm-specific information about number, weight and energy requirements per category, milk production level and protein and urea contents of the milk, and the composition of roughages (herbage, silage maize) and purchased concentrates. Such a method allows for an accurate estimation of N and P excretion and manure N and P production at farm level.

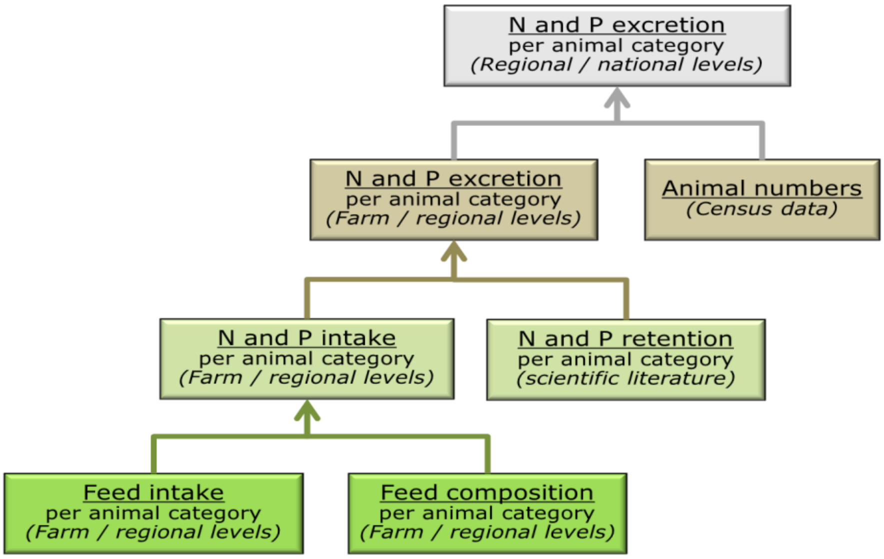

Figure 1. Flow of data and information for estimating N and P excretion at regional and national scales

However, data availability is a major bottleneck and the general flow diagram presented in Figure 1 cannot be applied easily to all Member States of the EU-27. Full use of the input-output balance method, which in principle provides the most accurate estimates of N excretions per animal category in practice, requires well defined inputs and the availability of these inputs to monitoring and registration desks. This latter is not the case in all Member States. Therefore, we propose a tiered approach, which provides flexibility and yet uniformity.

The variation in data availability can be represented by three different levels from Tier 1 (low data availability) to Tier 3 (high data availability). The accuracy of the calculated excretions increases from Tier 1 to Tier 3, similar to a tiered approach used in the UNFCCC emission accounting.

Tier 1

At Tier 1 no specific country data are available and calculation of N and P excretions is not possible. In that case default values have to be used. Default values can be derived from (inter)national literature and are constant over years until updates are made. Update intervals should be not more than 3 to 5 years, because of technical progress in animal production. When using Tier 1, variations between years in excretions are caused by changes in animal numbers only.

Tier 2

At Tier 2 data are available to calculate mineral intake and mineral retention per animal per year. However, data to calculate the building blocks for these calculations (feed intake, feed composition, animal product and composition of animal product) are not available on a yearly basis. They are derived from literature or from experimental farms and are updated in intervals of 3-5 years.

Tier 3

At Tier 3 all data for measuring the basic building blocks (feed intake, feed composition, animal product and composition of animal product) are available on an annual basis, and updated every year.

Data origin

These three levels could be used as three different methods (tiers) to calculate the annual N and P excretions per country. However, the accuracy of the calculated excretions will vary with the tier chosen, due to differences in the origin and quality of the data.

To calculate N and P excretion on a national level several data origins can be distinguished. Table 3 shows five different data origins of decreasing quality (1 is the best). These five data origins could be combined with quality parameters as 'statistical reference' and 'update interval'. Statistical reference is used as an abbreviation for data that are based on a referred national inventory. The combination of 'update interval' and 'reference' can be used to compare different data origins. Table 3 presents a combination of possibilities, as an example.

Conclusion

A common methodology for the estimation of annual N and P excretions per animal category per country must account for differences between countries in data availability. A 3-tier approach is probably the best approach, with tier 1 having national default values and tier 3 values derived from a detailed account of the balance method. The second level is based on a combination of defaults, measurements and simulation modelling. Effects of data quality on accuracy of the calculation of the annual excretions are large. Therefore, data origin have to be defined including references and update intervals.

Table 3 Data origin and data quality per country under consideration

Data origin	Statistical reference		Update interval in years			
			1	2-5	5-10	>10
	Yes	No				
1 Measurements input-output						
Animal	x		x			
Farm	x			x		
Region	x				x	
Country	x					X
2 Modelling approach						
Animal	x		x			
Farm	x			x		
Region		x	x			
Country		x		x		
3 Measurements manure						
animal category		x	x			
animal species		x		x		
Farm		x			x	
Country		x				X
4 Defaults						
animal category	x			x		
animal species	x				x	
common literature		x		x		
country specific information		x			x	
5 Expert judgement						
animal category	x				x	
animal species	x					X
common literature		x			x	
country specific information		x				x

1 Introduction

Livestock production systems exert various influences on the environment. The influences greatly depend on the livestock production system itself, the management and the environmental conditions. Much of the influence on the environment occurs via feed production, manure utilization and through emissions association with animal production. The Gross Nitrogen Balance (GNB) is a key indicator for assessing the effects of agriculture on the environment. For establishing accurate GNBs, accurate information is needed of all input and output items of the GNB, at national and preferably regional scales.

The amount of nitrogen (N) in manure entering agricultural land and the amount of N leaving agricultural land in harvested grass, either via grazing or mowing, are the least accurate items on the GNB, because these flows are not measured at farm or national level. In fact, these flows are extremely difficult to measure directly; they can more easily be quantified in an indirect way. Currently, there are no uniform, standard and accepted methodologies and terminologies for estimating the amounts of N and P in animal excrements. Member States tend to use methods which they have developed and improved over time, and sometimes use different methodologies for different reporting requirements, as reported by the DireDate project (http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-11-005/EN/KS-RA-11-005-EN.PDF). This make comparisons between countries and estimates at EU-27 level complicated.

Globally, approximately 70% of the agriculturally used land area is for the production of feed. However, only 40 to 60% of the carbon (C) and 10 to 50% of the nitrogen (N) and phosphorus (P) in feed are retained by the animals in meat, milk and egg, while the remainder is excreted in urine and faces. As such, livestock excreta is a large source of C, N, P and other (micro) nutrients, to be used for increasing soil fertility and crop yields. Globally, livestock excretes about 100 Tg) N per year (range 70-140 Tg, but only 20-40% of this amount is recovered and applied to crop land. Most of the remainder is dissipated into the environment. The amounts of P and potassium (K) in livestock manure are roughly 1.5 and 3 times the current amounts of P and K in mineral fertilizers, respectively.

The total amount of N excreted by livestock in the 27 Member States of the European Union (EU-27) is in the range of 10-11 Tg and the total amount of P excreted ranges between 1.5 and 2.5 Tg per year. These amounts are in the same order of magnitude as the amounts of N and P in fertilizers in EU-27. However, the estimated N and P excretions are uncertain. Member States in the

EU-27 estimate N and P excretions for the purpose of the estimation of N and P inputs to agricultural land, (gross) N and P balances, ammonia emissions, and greenhouse gas emissions. Currently, consistency is lacking (i) at national level for excretion coefficients used for different policies, and (ii) at EU-27 level, for excretion coefficients used by Member States. These inconsistencies arise from the use of different methodologies and the use of different data (quality).

In response, the European Commission initiated by the end of 2012 the study ' Nitrogen and phosphorus excretion coefficients for livestock" , which is Lot 1 of "Methodological studies in the field of Agro-Environmental Indicators" (2012/S 87-142068). The general objective of the Lot 1 study is '*to bring clarity into the issue of excretion coefficients so that a recommendation on a single, common methodology to calculate N and P excretion coefficients can be identified*' . Recommendation for a uniform and standard methodology for estimating N and P excretion coefficients must be based on a thorough analysis of the strength and weaknesses of the existing methodologies and on the data availability and quality in the Member States. Therefore, the specific objectives of the study are:

- To create an overview of the different methodologies used in Europe to calculate excretion coefficients for N and P, and analyse their strengths and weaknesses;
- To set up a database with the excretion coefficients presently used in different reporting systems and describe the main factors that cause distortion within a country and across the EU;
- To provide guidelines for a coherent methodology, consistent with IPCC and CLTRP guidelines, for calculating N and P excretion coefficients, and taking into consideration the animal balance and taking into account different methodologies identifies under the first bullet point;
- To create default P-excretion coefficients that can be used by the countries who do not have yet own factors calculated;
- To identify the main components of the calculations of excretion coefficients and the data requirements for these components in such a detail that they allow introducing them in data collection systems.

Within this study the following seven tasks are distinguished, each with specific deliverables:

Task 1 Overview of existing excretion coefficients

Deliverables:

- a database covering all EU member states with the different excretion coefficients used;
- a report per country on the methodologies used for the different factors.

Task 2 In-depth analyses of selected country reports

Deliverable:

- a report per country on the methodologies used for the different factors, the reasons for the choice of the particular method, the strengths and weaknesses of the approaches and other similar issues, including the NUTS level involved in calculations

Task 3 Analyses of the coherence, differences and best practices
Deliverables:

- a report on the coherence and differences of the different methodologies used for reporting on excretion
- a report on the comparability of the different data flows and on the coherence of the data reported to different institutions
- a report on best practices across EU.

Task 4 Regional representativeness
Deliverable:

- a report on the need for regional excretion coefficients and data to be collected at regional level

Task 5 Guidelines for a common methodology
Deliverables:

- draft guidelines for potential common methodologies for estimating N and P excretion coefficients to be discussed in the workshop in Task 7
- final guidelines based on the workshop in Task 7.

Task 6 Default P excretion coefficients
Deliverable:

- A report establishing default values for components in the calculation of P excretion coefficients.

Task 7 Expert/ statistician workshop
Deliverables:

- Support to organising the workshop
- A workshop document summarising the outcome of Tasks 1-6, with specific focus on Task 5
- The minutes of the workshop.
- The revision of the preliminary results of task 5, on the basis of the conclusions of the workshop.

The task reported here (*Task 3 Analyses of the coherence, differences and best practices*) builds further on the analyses carried out in Tasks 1 and 2. It reports on the coherence and differences in the methodologies for estimating N and P excretion coefficients in Member States and identifies best practices. The main aims are:

- To analyse the coherence and differences of the methodologies used to estimate N and P excretions;
- To identify the main components (building blocks) of the methodologies
- To analyse the comparability of the reported N and P flows, balances and emissions, both within countries and between countries, when using different methodologies for calculating excretion coefficients;
- To identify best practices for calculating N and P excretion coefficients.

In Chapter 2, a summary is presented of the main findings of Task 1 and Task 2. The following chapter 3 provided an overview of the main 'building blocks' of the methodologies for the calculation of N excretion, and describe the similarities and differences between different methodologies. Chapter 4 then briefly describes the comparability of the reported N and P flows, balances and emissions, both within countries and between countries, when using different methodologies for calculating excretion coefficients. Thereafter, we derive 'Best practices for calculating N and P excretion coefficients' in Chapter 5. Finally, the main conclusions and recommendations are summarized in chapter 6.

2 Summary main findings of Tasks 1 and 2

2.1 Introduction

Member States of the EU-27 collect, process and use data and information about N and P excretion by livestock for various policy reports and studies. In Tasks 1 and 2 of the current study, information about N and P excretion coefficients, manure production volumes, N and P contents of manure and gaseous N losses from manure storages were reviewed. For each of the reports, the methodology applied, the N and P coefficients per animal category, and the spatial scale were recorded. In addition, assessments were made of the completeness, strength and weaknesses of the methodology, the data and information used, and the quality control procedures. The following reports have been reviewed:

- OECD/Eurostat reports on Gross Nitrogen and Phosphorus Balances;
- Member States' Action Programmes under the EU Nitrates Directive;
- Member States' inventories of greenhouse gas emissions under the UNFCCC
- Member States' inventories of ammonia emissions under the UNECE-CLRTAP and EU-NEC;
- The FAO Life Cycle Analysis (LCA) of livestock production;
- The IIASA methodology applied in the model RAINS/GAINS
- The methodology applied in the GGELS project;
- General scientific literature about N and P excretion coefficients;

Results of the inventory were stored in a database with N and P excretion coefficients per animal category and Member States. Next, systematic and in-depth analyses were made of selected countries, and the strength and weaknesses of the methodologies, their data requirements, accuracy and practical feasibility were assessed. In this chapter, we briefly summarize the main findings of Task 1 and Task 2.

Table 1. Percentage of dietary N and P excreted by livestock (adapted from Ryser et al., 2001)

Type of Animal	N excreted (% of feed Intake)	P excreted (% of feed Intake)
Dairy Cow	65-80	65-80
Growing Cow (beef)	75-80	70-85
Sow with piglets	75-80	75-85
Finishing Pig	70-80	75-85

Laying Hen	65-80	85-90
Broiler	55-65	50-65

The main factor that influences the content of N and P in animal excreta is diet. In fact, more than 50 % of the N and P contained in animal feed is excreted (Table 1). Within species, the exact proportion excreted varies according to a range of factors including performance (e.g. amount of milk, meat and egg produced), age, sex and husbandry. Pigs and poultry, which are subject to relatively less variability in feeding regimes across EU Member States, should therefore present less variability in their excretion than cattle, sheep and goats. This also implies that consideration of the data produced by different MS cannot be separated from the differences in quality and use of the main products, whether milk, meat or eggs. Thus, pig diets for bacon production are not the same as for dry ham; and the diet used for dairy cattle can vary substantially between those for direct consumption milk to milk produced for cheese making. Calculated values for excretal output vary greatly, reflecting differences in feed intake due to diet and levels of production.

2.2 Task 1. Overview of existing excretion coefficients; an inventory of methods

Most of the pertinent policies require the reporting of gross N and P excretion (ex animal) per animal category. However, some policies (e.g. Nitrates Directive, Gross Nitrogen Balances, national policies on fertilization planning) require the reporting of N excretion corrected for gaseous N losses during storage (ex storage). The latter is also called 'manure N and P production', which for P is assumed to be equal to P excretion. Generally, three pertinent scales are distinguished, i.e., farm level, regional level (which can be an administrative unit, i.e., district, county, NUTS 2, or a catchment) and national scale, depending on the purpose of the accounting. In animal sciences research, the individual animals are often object of study, also to find out (genetic) differences between animals and their response to management factors, including animal diets. However, the latter is beyond the scope of this study.

Roughly three methodologies for the estimation of N and P excretion and production are applied by Member States, i.e., (i) default coefficients, based on literature studies and expert judgement, (ii) input-output balance calculations, and (iii) measurements of the volume and N and P contents of manure produced. The most common method is the input-output balance calculation, which assumes that the amount of N and P excreted in faeces and urine is equal to the total amount of feed N and P consumed minus the N and P retained in marketed products (milk, meat, eggs, live weight gain), respectively. Hence, excretion = intake – retention. All methodologies allow in principle for making adjustment according to the length of the production cycle and for non-use of the stock accommodation, to provide an annual output factor per "animal place". The latter is necessary to allow for non-productive time needed for cleaning and re-stocking the housings.

Input-output balances require the estimation of the intake of N and P via feed, and of the N retention in animal products. The amounts of N and P consumed by the animal depends on the amount of feed digested by the animal, and the N and P contents of that feed. Total feed intake depends on the maintenance cost and production level of the animal (e.g., growth rate, milk and egg production), and the feeding value and digestibility of the feed. Data on the annual N and P retention in meat, egg, milk, or wool produced is usually derived from production statistics and scientific reports about the N and P contents in animal products.

For reporting emissions of ammonia from agriculture to the UNECE-CLRTAP and EU-NEC, detailed guidelines are provided by the EMEP/EEA Air Pollutant Emission Inventory Guidebook, which include recommendations for the calculation of N excretion coefficients, at two Tier levels. Our inventory indicates that 18 Member States use default N excretion coefficients and 9 use country specific methodologies. The OECD/Eurostat Nitrogen and Phosphorus Balance Handbooks provide also guidance to the calculations of N and P excretion coefficients. When N and P excretion coefficients are not compliant with the guidelines in the OECD/Eurostat Handbook, OECD/Eurostat take estimates from pertinent country reports to the UNFCCC.

Our review indicates that the N excretion coefficients per animal category may vary by up to a factor of 2 between Member States. The same holds for P excretion. Interestingly, estimated N excretion coefficients per animal category may vary up to 20% for a Member State, depending on the (policy) reports.

An analyses of the UNFCCC national inventory reports 2011 shows that most member states use a country specific approach for N excretion estimates (

Table 2). The reported N excretion values per animal category differ significantly between Member States (roughly by a factor of 2, but sometimes by a factors of 3). These differences indicate differences in animal productivity and animal feeding, but reflect to some extent also differences in methodologies.

Error! Reference source not found.3 presents an overview of the methodologies used for the estimation of N and P excretion coefficients in the OECD/Eurostat N balance. Also here, most countries use a country specific methodology.

Table 2. Methodology for the estimation of N excretion by livestock, as indicated in UNFCCC National Inventory Reports 2011.

Member state	UNFCCC; NIR 20011
	N excretion
Austria	Country specific
Belgium	Country specific
Bulgaria	IPCC default
Cyprus	IPCC default
Czech Republic	IPCC default
Denmark	Country specific
Estonia	IPCC default, except dairy cattle
Finland	Country specific
France	IPCC default
Germany	Country specific
Greece	IPCC default
Hungary	IPCC default
Ireland	Country specific
Italy	Country specific
Latvia	Country specific
Lithuania	IPCC default, except dairy cattle and pigs
Luxembourg	Country specific (Nitrates Directive)
Malta	Country specific
Netherlands	Country specific
Poland	Country specific
Portugal	Country specific
Romania	IPCC default
Slovakia	IPCC default
Slovenia	Country specific
Spain	Country specific
Sweden	Country specific
United Kingdom	Country specific

Table 3. Methodology for the estimation of N and P excretion by livestock, as indicated in the reports about Eurostat/OECD N and P balances.

	N excretion	P excretion
Austria	Country specific	Country specific
Belgium	Country specific	Walloon; Eurostat
Bulgaria	Eurostat uses UNFCCC figures	Eurostat
Cyprus	Eurostat uses UNFCCC figures	Eurostat
Czech republic	Country specific	Country specific
Denmark	Country specific	Country specific
Estonia	Not available	Not available
Finland	Country specific	Country specific
France	Eurostat uses UNFCCC figures	Eurostat
Germany	Country specific	Country specific
Greece	Eurostat uses UNFCCC figures	Eurostat
Hungary	Country specific	Not available
Ireland	Country specific	Eurostat
Italy	Country specific	Eurostat
Latvia	Eurostat uses UNFCCC figures	Eurostat
Lithuania	Eurostat uses UNFCCC figures	Eurostat
Luxembourg	Eurostat uses UNFCCC figures	Eurostat
Malta	Country specific	Eurostat
Netherlands	Country specific	Country specific
Poland	Country specific	Country specific
Portugal	Country specific	Country specific
Romania	Eurostat uses UNFCCC figures	Eurostat
Slovakia	Country specific	Country specific
Slovenia	Country specific	Eurostat
Spain	Country specific	Not available
Sweden	Country specific	Country specific
United Kingdom	Not available	Not available
Norway	Country specific	Country specific
Switzerland	Country specific	Country specific

Error! Reference source not found.4 presents an overview of the methodologies used for the estimation of manure N production, as reported by Member States in the Action Programmes of the Nitrates Directive. Nine Member States estimate manure N production from the volume of manure N produced multiplied by the mean N content of the manure. Other Member States have adopted the UNFCCC methodology for estimation of N excretion and apply a correction factor for gaseous N losses during storage.

Table 4. Methodology for the estimation of N excretion by livestock, as indicated in the Action Programs of the Nitrates Directive.

Country	Nitrates Directive
Austria	Country specific net excretion
Belgium	As UNFCCC for Flanders: net excretion Gross excretion for Walloon
Bulgaria	N content and volume of manure***
Cyprus	N content and volume of manure
Czech Republic	N content and volume of manure
Denmark	N balance as UNFCCC; corrected for gaseous N loss
Estonia	N content and volume of manure
Finland	N balance.
France	N balance; corrected for gaseous N loss
Germany	Country specific gross excretion. Method not indicated
Greece	N content and volume of manure
Hungary	Country specific net excretion, based on literature
Ireland	N balance (as Nitrates Directive)
Italy	N balance
Latvia	N content and volume of manure
Lithuania	Net excretion based on N balance and gaseous N loss
Luxembourg	Not indicated
Malta	Not indicated
Netherlands	Same as UNFCCC, but other year. Includes correction for gaseous N losses
Poland	N content and volume of manure
Portugal	N content and volume of manure
Romania	Based on UNFCCC figures
Slovakia	N content and volume of manure
Slovenia	Country specific net excretion. Method not indicated
Spain	Country specific gross excretions. Method not indicated
Sweden	STANK model. Methodology not clear
United Kingdom	N balance.

*N balance of the animal: N input as feed – N output as animal products

** Emission of NH_3 is expressed in kg NH_3 per animal; N excretion is not used in Tier 1 approach

*** The manure production/ N excretion calculated from volume of manure and the N content of the manure

Table 5 summarizes the methodologies for the calculation of N excretion / manure N production in Member States as reported in the inventories of greenhouse gas emissions (UNFCCC), ammonia emission (UNECE Gothenborg protocol) and those used for the Action Programme of the EU Nitrates Directive. Below the main findings for each country are presented.

Table 5. Comparison of methodologies for the estimation of N excretion by livestock, as indicated in reports on greenhouse gas emissions (UNFCCC), ammonia emission (UNECE Gothenborg protocol) and Action Programs of the EU Nitrates Directive.

Country	**UNFCCC**	**Gothenborg protocol**	**Nitrates Directive**
Austria	N balance*		Country specific net excretion
Belgium	Country specific (N balance?)		As UNFCCC for Flanders. Gross excretion for Walloon
Bulgaria	IPPC default	EEA/EMEP default; NH_3 based**	N content and volume of manure***
Cyprus	IPPC default	EEA/EMEP default; NH_3 based	N content and volume of manure
Czech Republic	IPPC default	Not clear	N content and volume of manure
Denmark	N balance		N balance as UNFCCC; corrected for gaseous N loss
Estonia	IPPC default, except dairy cow	EEA/EMEP default; NH_3 based	N content and volume of manure
Finland	N balance. Different values between UNFCCC, Gothenborg and Nitrates Directive; not clear		
France	IPPC default	EEA/EMEP default; NH_3 based	N balance; corrected for gaseous N loss
Germany	N balance	Region specific N balance	Country specific gross excretion. Method not indicated
Greece	IPPC default	Not indicated	N content and volume of manure
Hungary	IPPC default	EEA/EMEP default; NH_3 based	Country specific net excretion, based on literature
Ireland	N balance (as Nitrates Directive)	EEA/EMEP default; NH_3 based	N balance (as Nitrates Directive)
Italy	N balance		N balance. Not clear if this similar as for UNFCCC and Gothenborg protocol
Latvia	N balance	EEA/EMEP default; NH_3 based	N content and volume of manure
Lithuania	N balance for cattle and pigs. Other default IPCC	EEA/EMEP default; NH_3 based	Net excretion based on N balance and gaseous N loss
Luxembourg	Country specific; method not indicated	EEA/EMEP default; NH_3 based	Not indicated
Malta	Country specific; method not indicated	Not indicated	Not indicated
Netherlands	N balance		Same as UNFCCC, but other year. Includes correction for gaseous N losses
Poland	Country specific for dairy cattle, pigs, and horses	EEA/EMEP default; NH_3 based	N content and volume of manure
Portugal	Dairy based on milk country. Other livestock country specific. Method		N content and volume of

	not clear.		manure
Romania	IPPC default	EEA/EMEP default; NH_3 based	Based on IPCC figures
Slovakia	IPPC default	EEA/EMEP default; NH_3 based	N content and volume of manure
Slovenia	Dairy cattle based on milk production. Other not clear.	EEA/EMEP default; NH_3 based	Country specific net excretion. Method not indicated.
Spain	N balance		Country specific gross excretions. Method not indicated.
Sweden	STANK model. Methodology not clear.		
United Kingdom	N balance. Differences may occur because of different livestock categories and years		
Norway	N balance		--
Switzerland	Agrammon model. Dairy cattle based on milk yield. Pigs based on protein content feed		--

*N balance of the animal: N input as feed – N output as animal products

** Emission of NH_3 is expressed in kg NH_3 per animal; N excretion is not used in Tier 1 approach

*** The manure production/ N excretion calculated from N content and volume of manure

Austria uses the same approach for N excretion for reports to UNFCCC and IPCC. The method is based on the balance method of Ketelaars and Van der Meer (1999). Net excretions are reported for the Nitrates Directive for different housing systems. The assumptions of the gaseous N losses to calculate net excretion from gross excretion are not presented in the action programme. It is not possible to calculate the gross excretion from the data available in the Action Programme. The animal categories in the Action programme for the Nitrates Directive are more detailed than those used for UNFCCC and UNECE reports. The N excretion in the Action programme for the Nitrates Directive is based on stall place per year and those for UNFCCC and UNECE on animal per year. The N excretion values in the Action Programme for the Nitrates Directive depend for dairy cows on milk yield and those for piglets, fattening pigs, and breeding pigs on the feed.

Belgium Flanders uses the same methodology to calculate excretion for the report for Nitrates Directive, UNFCCC, and UNECE. In all three reports, gross excretions are presented. Walloon uses the same approach for UNFCCC and UNECE. For the Nitrates Directive, net excretions are presented. Gaseous N losses are not presented in the Action Programme of Walloon, so that it is not possible to calculate the gross N excretions.

Bulgaria uses a Tier 1 approach for the UNFCCC report and, by that, Tier 1 default excretion values; Bulgaria uses a Tier 1 approach for the Gothenborg protocol, i.e. a method based on NH_3 emission factors per animal and not based on excretion;. Bulgaria uses for the Nitrates Directive an approach in which the manure N production is calculated from the volume of manure produced and the N content of manure. No excretion figures are presented in the action programme.

Cyprus uses the Tier 1 excretion coefficients from the IPCC Guidelines for Near East and Mediterranean. Cyprus uses a Tier 1 approach for the Gothenborg protocol, i.e. a method based on NH3 emission factors per animal and not based on excretion. Cyprus uses for the Nitrates Directive an approach in which the manure N production is calculated from the volume of manure produced and the N content of manure. No excretion figures are presented in the action programme.

Czech Republic uses IPCC defaults excretion coefficients for the UNFCCC report. The approach of how Czech Republic calculates ammonia emission for the Gothenborg protocol is not clear from the report. Probably, ammonia emission factors per animal are used. Czech Republic uses for the Nitrates Directive an approach in which the manure N production is calculated from the volume of manure produced and the N content of manure. No excretion figures are presented in the action programme.

Denmark uses the same approach for N excretion for the UNFCCC report and Gothenborg protocol report. It is not clearly indicated how the N excretion is calculated, but it its very likely that the same approach is used as for the Nitrates Directive. The Danish normative system is used to calculate the N excretion for the Nitrates Directive. This is an " input – output" system based on values coming from actual farm statistics. Default values are given for a " standard mean animal" and there are possibilities for farmers to correct default values if the dietary protein level is lower than the default value, or different body weigths, or age of animals. The table for the Nitrates Directive does not included gaseous N losses from housing and storage, so that no calculation of the gross excretion can be made from the presented net excretion.

The N excretion used for the UNFCCC report of **Estonia** is calculated by multiplication of the N content of manure with the manure excretion per head. The manure excretion is estimated and the N content based on literature. This suggests that Estonia uses the net excretion instead of the required gross excretion for the UNFCCC report. Nitrogen excretion coefficients for other livestock categories were obtained from the Revised 1996 IPCC Guidelines. Estonia uses a Tier 1 approach for the Gothenborg protocol, i.e. not based on N excretion but on NH_3 emission factors per animal. The calculation of manure production in Estonia is based on volumes and N content of produced manure. The N excretion figures are not shown in the Action programme.

Finland uses animal specific nitrogen excretion rates, based on nutrient balance calculations. Excretion rates are obtained by subtracting the nitrogen included in animal products and growth from the nitrogen intake through feeding. The source of excretion rates is the same for UNFCCC report, Gothenborg protocol report, Nitrates Directive, and Eurostat balance (MIT Agrifood Research Finland). Most likely, the same methodology is used. However, there are some discrepancies between the source which are not clear. For example, the N excretions from dairy cattle is somewhat different between the UNFCCC report and the Gothenborg protocol report. Also the excretion rates in 2009 differ between these two reports. Moreover, it is not indicated if the figures for the Nitrates Directive are net or gross excretion rates. The excretion rates of dairy cattle are similar than those Gothenborg protocol, suggesting that they are gross excretion rates (or low gaseous emissions have been assumed. Those of sows, fattening pigs, and poultry are lower for the Nitrates Directive than Gothenborg protocol, suggesting that these are net excretion rates.

Germany uses for both UNFCCC and Gothenborg protocol a N feed balance methodology to calculate N excretion. The values for UNFCCC are only presented for the main categories on an national level, but the values for the Gothenborg protocol are presented on a regional basis for a large number of animal categories. Only one animal category is the same: dairy cows. The net excretion of a dairy cow in 1998 was 121.8 kg N per place per year for UNFCCC and 106.4 kg N per place per year for the Gothenborg protocol. Although the method is the same, the calculated excretion differs between the UNFCCC and Gothenborg reports. The reason for the different is not indicated in either UNFCCC or the Gothenborg reports. The excretion table for the Nitrates Directive contains detailed information about the gross N excretion. The level of detail and the fact that there are differences due weight, milk production and feed suggests that these excretion values are based on N balance calculations. The livestock categories are different from those used for UNFCCC and Gothenborg reports, so that an comparison cannot be made. The values used for UNCCC and Gothenborg appear to be derived more recently than those of the Nitrates Directive.

Hungary uses IPCC default excretion values. It is assumed that production level and feeding technology of animal breeding in Hungary are close to the Western European standards, therefore the default IPCC factors for Western Europe are used. Hungary uses a Tier 1 approach for the report for the Gothenborg protocol, i.e. not based on N excretion but on NH_3 emission factors per animal. The net excretion coefficients and correction factor for gaseous N losses used by Hungary for the Nitrates Directive has been derived from domestic and international literature sources.

Ireland uses the same approach for the UNFCCC and Nitrates Directive. The approach used for the Gothenborg protocol is not based on excretion coefficients.

Both the UNFCCC, Gothenborg and Nitrates Directive reports indicate that **Italy** uses a N feed balance approach to calculate N excretion. In these reports it is referred to the interregional project "Nitrogen balance in livestock farms", suggesting that the same methodology to calculate N excretion is used for these three reports (Note: it is certain that Italy uses exactly the same N balance method for UNFCCC report and Gothenborg protocol). Latvia uses an N balance approach was used for estimating N excretion by farm livestock. Information on both input (N intake) and output (N products) factors are used. The N intake is calculated as feed intake (kg of dry matter) x content of the feed while N products includes the N in live weight gain, milk, etc.

Latvia uses a Tier 1 approach, i.e. not based on N excretion but on NH_3 emission factors per animal. The calculation of manure production for the Nitrate Directive is based on manure volume and N content of produced manure. The N excretion figures are not shown in the Action programme

Lithuania uses a feed balance approach to calculate excretion for cattle and pigs for UNFCCC report. For other categories default values are used. The Tier 1 approach is used for Gothenborg protocol, i.e. not based on N excretion but on NH_3 emission factors per animal. Lithuania uses a feed balance approach to calculate excretion for the Nitrates Directive. Both net and gross excretion values are presented. It is not clear from the documentation if the approach for UNFCCC report and Nitrates Directive for cattle and pigs are equal, but the fact that excretion for dairy cattle differs between UNFCCC and Nitrates Directive indicates that the methodology (or input parameters) are not the same.

Luxembourg states in the report for the UNFCCC that most of the excretion coefficients have been prepared in the framework of the Nitrates Directive and good agricultural practice and/or for the OECD Agro-environmental Indicators Database. The methodology is not described. Luxembourg uses a Tier 1 approach for the Gothenborg protocol, i.e. not based on N excretion but on NH_3 emission factors per animal. No information was found about the methodology used by Luxembourg to calculate manure N production for the Nitrates Directive.

The methodology of calculation of excretion for the UNFCCC by **Malta** is not clear. The excretion values or other information about manure production is not presented in the Action programme of Malta for the Nitrates Directive.

The **Netherlands** uses the same methodology for calculation of N excretion for the Gothenborg protocol and UNFCCC report. The Netherlands uses legally determined forfeits for cattle and other grazing livestock and a stable balance for stabled livestock such as pigs and poultry. The excretions for dairy cows are linked to milk production on the farm concerned, and adjusted accordingly. This methodology to derive forfeits is based on a N balance. For the Nitrates Directive, the same N balance methodology is used as for UNFCCC report and Gothenborg protocol. However, for UNFCCC and Gothenborg, the excretion is calculated every year using year specific values of inputs and outputs. The excretion for the Nitrates Directive is based on assumptions about average inputs and outputs, and are not related to a specific year.

Poland calculates the nitrogen excretion rates for UNFCCC report using a model (SFOm) for cattle, horses and swine. However, it is not clear which methodology is used. Poland uses a Tier 1 approach for the Gothenborg protocol, i.e. not based on N excretion but on NH3 emission factors per animal. The calculation of manure production for the Nitrates Directive is based on volumes and N content of produced manure. The N excretion figures are not shown in the Action programme.

Portugal uses the country specific methodology to estimate excretion for the UNFCCC report and Gothenborg protocol (the same method is used). The quantity of nitrogen excreted per head is derived from expert information provided by the Ministry of Agriculture. The nitrogen excretion rates were taken from the - Analysis of the new nitrogen excretion rates proposed in the revision of the Agriculture Good Practice Code (CBPA – Código de Boas Praticas Agrícolas). CBPA defines the nitrogen excretion rate of dairy-cattle as a function of their milk production. The methodology used to derive the N excretion values of the other livestock categories is not described. The calculation of manure production is based on volumes and N content of produced manure . The N excretion figures are not shown in the Action programme.

Romania uses default IPCC values for Eastern Europe for UNFCCC report and a Tier 1 approach based on NH_3 emission factors per animal for the Gothenborg protocol (not based on excretion). The Action Programme for the Nitrates Directive for Romania is currently under revision. Romania will base the N excretion figures for the Nitrates Directive on the IPCC defaults.

Slovakia uses the IPCC excretion defaults for the UNFCCC report. Slovakia uses a Tier 1 approach for the Gothenborg protocol based on NH_3 emission factors per animal. The calculation of manure production for the Nitrates Directive is based on volumes and N content of produced manure.

Slovenia uses a country specific approach for N excretion rates for cattle and pigs. The nitrogen excretion for dairy cows has been linked to the milk production. The methodology for estimation of the excretion of other livestock categories is not described. Slovenia uses a Tier 1 approach for the Gothenborg protocol, based on NH_3 emission factors per animal. Slovenia uses country specific net nitrogen excretion rates for the Nitrates Directive. The methodology how these excretions factors have been derived is not presented in the Action Programme.

The N excretion values for UNFCCC and Gothenborg reports of **Spain** have been obtained through calculation of nitrogen balances for the cattle, pigs, poultry, and sheep. The N excretion of the other categories are based on the IPCC default for “Near East and Mediterranean”. The action programme for the Nitrates Directive of Spain includes a table with gross N excretion rates. The methodology is not indicated. The values are different than those used for the reports for UNFCCC and Gothenborg protocol.

The N excretions factors in the **UK** used for UNFCCC, Gothenborg protocol, and Nitrates Directive are derived from N balance calculations. The methodology is the same for these three reports, but differences may occur because of different animal categories and different years that are considered.

Norway uses a N balance approach to calculate N excretions for UNFCCC and Gothenborg protocol. The calculations are based on typical Norwegian feedstock ratios, the excretion of nitrogen (N) and phosphorous (P) were calculated by subtracting N and P in growth and products from assimilated N and P. The numbers were in some cases compared to numbers found in balance experiments.

Switzerland uses the Agrammon model to calculate N excretion used for UNFCCC and Gothenborg protocol. The N excretion of dairy cattle is dependent on the milk yield and that of pigs is based on the protein content of feed.

2.3 Task 1. Overview of existing excretion coefficients; an inventory of values

In this paragraph, a comparison is made of gross excretion rates for main livestock categories. For the Nitrates Directive, only for a limited number of member states gross excretion rates can be derived.

Dairy cattle (Table6)

- For nearly all countries, there are large differences in N excretion of dairy cattle between the considered sources. For Norway and Switzerland, differences between the sources are smallest, but no data for CAPRI and Nitrates are available for these countries.
- The excretion coefficients used for UNFCC (NIR 2011) and Gothenborg protocol are for most member states similar, except Germany (131.5 for NIR 2011 and 113.7 for Gothenborg).
- The CAPRI estimates are sometimes very high, e.g. 194 kg N/cow/year in Denmark and 180 kg N/cow/year in Sweden.

Table 6. Nitrogen excretion coefficients for dairy cattle as reported for Member States.

Comparison N excretion different sources: dairy cattle						
Country	GAINS 2010	NIR 2011	CAPRI	Gothenborg	Nitrates Directive	Eurostat/OECD
	Dairy cows	Dairy cows	Dairy cows	Dairy cows	Dairy cows	Dairy cows
Austria	106.0	97.1	90.0	97.0		97.4
Belgium	117.7	115.1	95.0			109.0
Walloon				120.5		111.4
Flanders				97.0	97.0	105.9
Bulgaria	75.3	70.0	116.0			
Cyprus	103.1	*	134.0			106.7
Czech Republic	131.1	144.8	114.0			105.3
Denmark	131.8	138.1	194.0	138.0		129.4
Estonia	113.0	102.1	122.0			62.1
Finland	120.6	126.9	92.0	121.9		
France	112.1	100.0	105.0			124.7
Germany	130.1	131.5	106.0	113.7	100 - 149	
Greece	111.1	100.0	97.0			
Hungary	146.5	114.1	149.0			125.0
Ireland	104.8	85.0	88.0		85.0	108.9
Italy	111.7	116.0	97.0	116.0		94.0
Latvia	87.9	70.0	139.0			70.0
Lithuania	95.0	99.2	99.0		120.0	
Luxembourg	114.3	102.0				71.0
Malta	98.0	*	155.0			102.7
Netherlands	146.8	127.0	119.0	130.2	99 - 131	134.5
Poland	80.8	86.7	91.0			70.0
Portugal	101.9	115.0	121.0	111.7		111.7
Romania	67.5	70.0	96.0			
Slovakia	134.6	100.0	119.0			105.0
Slovenia	110.1	110.6	85.0			113.0
Spain	70.8	67.7	108.0	67.7	89.0	103.3
Sweden	132.2	126.4	180.0	125.0	117 - 139	117.0
United Kingdom	133.3	110.0	142.0			117.0
Belarus	55.0	77.1				
Croatia	55.0	70.0				
Norway	82.0	82.0		82.0		84.8
Russia	55.0	94.5				
Switzerland	107.0	110.2		115.0		115.3
Turkey	66.5	82.6				
Ukraine	55.0	74.5				

Other cattle (Table 7)

- The group other cattle consists of categories with large differences in N excretion rates, from less than 15 kg N per animal for calves up to more than 75 kg N per animal for beef cattle and suckler cows. This hampers the estimation of an average excretion rates for a category "other cattle" , as included in GAINS, CAPRI, IPCC methodology, and Gothenborg reports. Probably, the excretion figures for other cattle in these sources are based on calculations for different specific categories, but are not presented .
- Large differences are sometimes shown for the different data sources. This is due to the large diversity of cattle categories, which needs to be taken into account for the calculation.
- There also large differences for specific categories, e.g. for suckler cows from 63 to 95 kg N per animal per year for the Nitrates Directive and from 64 to 98 kg N per animal for the Eurostat/OECD data base.
- For a transparent and accurate estimation of the excretion for other cattle than dairy cattle, it is recommended to use excretion figures for the detailed cattle categories (e.g. those in FSS) instead of using excretion figures for an "other cattle" category. This is also needed because the excretion rates have to be multiplied with the number of animals and information about how animal categories should be treated is needed.

Table 7. Nitrogen excretion coefficients for other cattle as reported for Member States.

Country	GAINS	NIR 2011	NIR 2011	CAPRI	Gothenborg	Nitrates Directive			Eurostat/OECD
	Other cattle	Other cattle	Young cattle	Other cattle		Suckler cows	Young cattle < 1 yr	Young cattle > 1 yr	Other cattle
Austria	45.8	46.6	*	40.0					78.5
Belgium	50.0	54.3	*	47.0					73.0
Walloon									65.0
Flanders							23.0	61.0	77.7
Bulgaria	45.0	50.0	50.0	49.0					
Cyprus	40.0	*	*	43.0					80.9
Czech Republic	45.0	70.0	*	43.0					78.6
Denmark	37.2	47.8	*	62.0	45.0				75.8
Estonia	45.0	44.4	16.7	42.0					62.1
Finland	53.0	50.2	*	30.0					96.5
France	50.0	57.5	*	53.0					68.7
Germany	39.9	40.8	*	40.0	44.3	87.0		60.0	
Greece	45.0	45.4	*	47.0					
Hungary	45.0	48.3	*	51.0					51.0
Ireland	68.9	48.9	*	48.0		65.0	24.0	57-65	79.8
Italy	46.9	48.7	*	39.0	49.8				73.8
Latvia	51.0	50.0	*	57.0					
Lithuania	50.0	57.6	*	38.0		95.0	33.0	60-69	
Luxembourg	42.0	68.0	40.0						
Malta	40.0	*	*	51.0					102.7
Netherlands	40.0	82.8	39.7	38.0		71.0	35.0	66.7	84.9
Poland	35.0	58.1	*	36.0					55.0
Portugal	49.9	51.2	*	68.0	80.0				80.0
Romania	52.5	50.0	*	39.0					
Slovakia	45.0	60.0	*	42.0					65.0
Slovenia	40.1	42.3	*	38.0					78.0
Spain	45.0	52.6	*	51.0	52.5				61.1
Sweden	39.0	41.7	*	61.0	63.0	63.0	22-34	47.0	63.0
United Kingdom	49.0	55.3	*	53.0					92.0
Belarus	45.0	36.4	*						
Croatia	45.0	50.0	50.0						
Norway	38.0	35.0	26.5						60.0
Russia	40.0	59.1	*						
Switzerland	36.0	80.0	33.4						80.0
Turkey	45.0	45.1	*						
Ukraine	45.0	68.4	29.7						

Pigs (Table 8)

The pig category consists of a large number of different pig types. This hampers the estimation of an average excretion rates for an average "pig category".

- Within a pig categories, there can be large differences, e.g for sows and for fattening pigs. This is partly due to differences in age and weight, and differences in feeding. However, it may not be excluded that some countries express the N excretion of an animal basis and other on animal places basis. For sows, it is important if piglets are included (and till which weight and age).

Poultry (**Error! Reference source not found.**9)

- There is a large diversity in poultry categories, which hampers the use of one excretion figure for one poultry category.
- There are sometimes large differences in N excretion for the same category between countries, which are not clear. This may be partly due to differences in age/weight, unit (animal or animal place).

Horses (**Error! Reference source not found.**10)

- An average figure of about 50 kg N per horse is often used. Countries use often the same excretion figures for horses for the UNFCCC report and Gotheborg protocol. Some countries differentiate the N excretion for different size of horses (e.g Flanders, Germany, Lithuania) showing differences between different horse classes.

Sheep and Goat (**Error! Reference source not found.**11)

- Large differences between sheep categories are shown, e.g. in the UNFCCC report N excretion ranges from 5.2 kg N for Spain to 20 kg N in Slovenia. Also the figures used for the Nitrates Directive show differences. These figures may partly be due to differences in the way male, female and young animals are considered in the excretion calculation

Fur animals and rabbits (**Error! Reference source not found.**12)

There are large differences in the N excretion of rabbits, probably due to differences in age, including/excluding young animals and the unit (per animal and animal place).

In conclusion, excretion coefficients differ between countries and also between policy reports for one and the same country. It is not always possible to find explanation for these differences, as the used methodologies are often not well described. Moreover, some data sources report aggregated excretion figures for animal categories (other cattle, pigs, and poultry), without showing the detailed N excretion rates for the specific animal categories. There is a clear need for a harmonized procedure to calculate N excretions and describe the methodology. The first step would be the definition of animal categories for which excretion figures have to be calculated. These are preferably categories for which animals number are gathered, so that total manure production in regions and countries can be made. It is recommended to use animal categories in FSS as a basis. The second step would be to recommend a set of methodologies (Tier approach) to estimate the N excretion for each category. The Tier 1 approach would be an approach with default N excretion figures for certain region or farming systems (depending on intensity). In other Tier levels, harmonized methodologies to calculate N excretion data are needed, which use available information for productivity and inputs.

Table 8. Nitrogen excretion coefficients for pigs as reported for Member States.

Country	GAINS	NIR 2011	CAPRI	Nitrates Directive			Gothenborg																
	Pigs	Pigs	Pigs	Sows	Fattening pigs	Boars	Pigs	Fattening pigs	Fattening pigs 20 - 110 kg	Fattening pigs > 110 kg	Fattening pigs 20-50 kg	Fattening pigs >50 kg	Sows	Sows incl. piglets	Sows, breeding	Sows, pregnant	Weaned pigs	Boars	Piglets < 20 kg	Piglets 7 - 20 kg	Piglets < 25 kg	Piglets 20-50 kg	Other pigs
Austria	9.0	9.6	17.3					10.3							29.1								
Belgium	11.1	10.1	18.4																				
Walloon											16.1		37.5					42.9		4.7		10.4	
Flanders				24.0	13-24	24.0			11.4	21.4				21.5				21.5		2.5			
Bulgaria	12.4	20.0	21.6																				
Cyprus	12.4	*	21.5																				
Czech Republic	12.4	20.0	19.8																				
Denmark	9.6	8.4	22.8				7.9																
Estonia	12.4	12.9	18.1																				
Finland	10.1	*	12.3					8.9						28.5			2.8	19.7					
France	12.2	16.5	16.6																				
Germany	14.8	12.1	18.4	24.7-34.9	11.9-13.6		12.1	12.6					27.9				3.1	27.8					
Greece	11.5	16.0	16.1																				
Hungary	8.9	8.1	26.9																				
Ireland	12.4	8.5	15.2	35.0	9.2																		
Italy	11.5	11.8	20.0										28.1										12.8
Latvia	10.0	10.0	24.4																				
Lithuania	12.4	12.3	17.5	28-43	5.4-6.2	28.4																	
Luxembourg	9.9	11.9																					
Malta	12.4	*	24.1																				
Netherlands	9.2	8.9	15.8	15.8-21.6	8.9	17.4		12.2					30.2		15.4			23.9					
Poland	11.1	13.6	16.6																				
Portugal	9.1	9.5	19.9								7.0	13.0			20.0	42.0		18.0					
Romania	12.4	20.0	18.8																				
Slovakia	12.4	15.8	18.0																				
Slovenia	11.9	11.9	15.0																				
Spain	9.4	9.4	17.5	11.5	9.8 - 11.5	24.4		7.5					22.2										
Sweden	11.0	9.1	21.3	36.0	11.0			10.8					34.0					34.0					
United Kingdom	12.4	10.6	17.6																				
Belarus	12.4	10.0																					
Croatia	12.4	20.0																					
Norway	10.7	6.4					4.4						18.3										
Russia	12.4	21.9																					
Switzerland	11.7	9.2						13.0					42.0					20.0			4.6		
Turkey	12.4	6.8																					
Ukraine	12.4	12.7																					

Table 8. Nitrogen excretion coefficients for pigs as reported for Member States (continued).

Comparison N excretion different sources: pigs

Country	Eurostat/OECD															
	Pigs	Pigs < 50 kg	Piglets < 20 kg live weight	Pigs 20 - 50 kg live weight	Fattening Pigs > 50 kg live weight	Fattening pigs between 50 and < 80 kg	Fattening pigs between 80 and < 110 kg	Fattening pigs of at least 110 kg	Breeding Pigs > 50 kg live weight	Boars	Sows	Covered sows	Covered sows - of which: sows covered for the first time	Sows not covered - total	Of which: gilts not yet covered	Other Pigs
Austria			3.6	10.3	10.3					23.9	20.6					
Belgium			2.4	11.3		11.3	11.3	19.9				20.9		20.1		
Walloon			2.3	11.2		11.2	11.2	19.8				20.9		20.5		
Flanders			3.6	12.8		12.8	12.8	21.4				21.4		12.8		
Bulgaria	20.0															
Cyprus			2.9	7.6	11.4					21.5	25.0					
Czech Republic			3.5	9.3	11.0					18.0	20.9					11.0
Denmark			1.8	5.6	14.6					20.6	23.1					23.1
Estonia			0.8	0.8		4.0	4.0	4.0		30.4	30.4	30.4		30.4		
Finland			3.4	10.2	12.0	12.0	12.0	12.0		22.1	25.5	25.5	25.5	25.5	25.5	
France		9.0	1.1	9.0	17.6					20.3	29.3					
Germany																
Greece																
Hungary	8.2	3.4			12.0				26.5							
Ireland			3.0	8.3	9.7					18.7	23.5					
Italy			4.0							21.0	26.0					12.0
Latvia	20.0															
Lithuania	11.6															
Luxembourg	10.0															
Malta			3.3	6.7	11.7	11.7	11.7	11.7	28.3	28.3	28.3	28.3	28.3	28.3	28.3	
Netherlands					12.9							30.8		13.5		
Poland			2.5	9.0	12.0					15.0	14.0					
Portugal				7.0	13.0					18.0		20.0		42.0		
Romania	20.0															
Slovakia			3.2	9.0	15.0					20.0	22.0					
Slovenia				14.0	14.0						36.0					
Spain	9.4	5.2	2.4	8.5	11.2	10.3	11.4	14.5	23.1	20.9	23.1					
Sweden			2.0	9.8	13.4					17.0		27.0		17.0		
United Kingdom			1.8	12.5		12.5	17.4	17.4		25.0		21.2	19.4	20.5	19.4	
Belarus																
Croatia																
Norway			0.4							16.0	22.1					4.0
Russia																
Switzerland					13.0					18.0		35.0		35.0		
Turkey																
Ukraine																

Table 9. Nitrogen excretion coefficients for poultry as reported for Member States.

Country	GAINS	GAINS	NIR 2011	CAPRI	Nitrates Directive			
	Laying hens	Other poultry	Poultry	Poultry	Laying hens	Broilers	Turkey	Duck
Austria	0.7	0.8	0.5	0.5				
Belgium	0.7	0.5	0.6	0.4				
Walloon								
Flanders					0.69	0.62	2.20	
Bulgaria	0.8	0.7	0.6	0.7				
Cyprus	0.8	0.7	*	0.6				
Czech Republic	0.8	0.6	0.6	0.6				
Denmark	0.7	0.5	0.5	0.8				
Estonia	0.8	0.5	0.6	0.6				
Finland	0.8	0.4	0.6	0.4				
France	0.8	0.9	0.6	0.6				
Germany	0.8	0.6	0.8	0.5	0.75-0.79	0.31-0.47	1.5-2.1	1.40
Greece	0.8	0.7	0.6	0.5				
Hungary	1.5	1.5	0.6	0.7				
Ireland	0.8	0.5	0.3	0.5	0.56	0.24	1.00	
Italy	0.7	0.5	0.5	0.5				
Latvia	0.9	0.9	0.6	0.8				
Lithuania	0.8	0.5	0.6	0.6	0.8-0.87	0.12	0.69	0.18
Luxembourg	0.8	0.7	0.7					
Malta	0.8	0.7	*	0.6				
Netherlands	0.7	0.6	0.7	0.5	0.37	0.36	1-1.5	0.63
Poland	0.7	0.6	0.3	0.6				
Portugal	0.6	0.9	0.6	0.6				
Romania	0.8	0.6	0.6	0.6				
Slovakia	0.8	0.7	0.7	0.6				
Slovenia	0.7	0.5	0.6	0.4				
Spain	0.8	0.7	0.5	0.6	0.80	0.60	0.80	0.40
Sweden	0.6	0.3	0.4	0.7	0.60	0.28		
United Kingdom	0.9	0.7	0.6	0.6				
Belarus	0.8	0.7	0.6					
Croatia	0.8	0.7	0.6					
Norway	0.7	0.5	0.2					
Russia	0.8	0.7	0.8					
Switzerland	0.7	0.4	0.5					
Turkey	0.8	0.7	*					
Ukraine	0.8	0.7	*					

Table 9. Nitrogen excretion coefficients for poultry as reported for Member States (continued).

Country	Gothenborg																	Eurostat/OECD										
	Laying hens	Laying hens, breeding	Laying hens < 18 wk	Laying hens > 18 wk	Broilers	Broilers, fattening	Broilers, parent animals , < 18 wk	Broilers, parent animals , > 18 wk	Turkey	Turkey, female	Turkey, male	Turkey, slaughter	Geese	Ostriches	Ducks	Pheasant	Other poultry then laying hens	Poultry	Chickens	Broilers	Layers	Other Chickens	Other Poultry	Ducks	Turkeys	Other Poultry Types	Geese	Ostriches
Austria	0.5																1.1			0.28	0.72	0.18		0.48	1.18	0.48		
Belgium																				0.55					1.70			
Walloon	0.8				0.4												0.6			0.54					1.70			
Flanders	0.7	0.4				0.6			2.01					10.61						0.60					2.20			
Bulgaria																		0.60										
Cyprus																				0.32	0.63		0.51					
Czech Republic																				0.35	0.60	0.30		0.70	1.20	0.70		
Denmark	0.8													15.6		0.04				0.63	1.11	0.14		1.51	2.58	1.82		
Estonia																				0.23	0.78	0.78	0.78					
Finland	0.7				0.4				1.371											0.37	0.78	0.27		0.59	1.84		0.55	
France																				0.48	0.64	0.95			1.50			
Germany	0.8		0.3		0.5				1.96	1.7	2.18		0.55		0.528			0.60										
Greece																												
Hungary																		0.69		0.38	0.74	0.38		0.38	1.65	0.38		
Ireland																				0.38	0.66		0.55					
Italy																				0.60			1.50					
Latvia																		0.60										
Lithuania																			0.79				1.10					
Luxembourg																		0.60										
Malta																				0.04	0.57							
Netherlands			0.3	0.8	0.5		0.35	1.11	1.91						0.79					0.53				0.76	1.71			
Poland																				0.14	0.70			0.70	1.50		1.50	
Portugal	0.8	0.6			0.5				0.48				0.48		0.48					0.45	0.80	0.60	0.48					
Romania																		0.60										
Slovakia																				0.30	0.70	0.50		0.70	1.50	1.00		
Slovenia																				0.40	0.71	0.40		0.60	1.50		0.73	
Spain	0.5				0.4												0.587			0.42	0.49		0.49					
Sweden	0.6				0.3															0.28	0.73	0.23						
United Kingdom																				0.51	1.89			1.60	1.74		1.74	
Belarus																												
Croatia																												
Norway		0.1			0.1					2		0.34		12						0.05	0.70	0.05	0.50					
Russia																												
Switzerland	0.8				0.5		0.34		1.4											0.45	0.80	0.34		0.45	1.40		1.40	17.50
Turkey																												
Ukraine																												

Table 10. Nitrogen excretion coefficients for horses, as reported for Member States.

Country	GAINS	NIR 2011	Nitrates Directive		Gothenborg									Eurostat/OECD					
	Horses	Horses	Pony	Horses	Horses	Horses < 200 kg	Horses 200-600 kg	Horses > 600 kg	Horses, heavy	Horses < 3 yr	Horses > 3 yr	Ponies	Mules and asses	Horses	Equidae	Foal < 1 year	Young horses 1-3 years	Horses > 3 years	Donkeys
Austria	47.9	47.9			47.9											12.7	44.6	52.6	
Belgium	50.0	58.4														54.0	54.0	65.3	50.7
Walloon																47.3	47.3	65.0	35.0
Flanders				35 - 65		35.0	50.0	65.0								65.7	65.7	65.7	65.7
Bulgaria	50.0	25.0												25.0					42.5
Cyprus	50.0	*													50.0				
Czech Republic	50.0	25.0												60.0					
Denmark	43.3	39.6			39.6									43.8					
Estonia	50.0	25.0												54.0					
Finland	50.0	61.2			60.9							43.5		49.0					
France	50.0	25.0												58.7					
Germany	47.9	49.0	32-42	45 - 64	49.0	33.4			53.6			33.4	33.4	25.0					25.0
Greece	50.0	40.0																	
Hungary	50.0	60.0												55.0					25.0
Ireland	50.0	44.0	30.0	25-50										64.0	50.0				
Italy	50.0	50.0			50.0								50.0	47.0					33.0
Latvia	51.0	48.0												25.0					
Lithuania	50.0	25.0		39-100										62.9					
Luxembourg	50.0	62.9												46.0					
Malta	50.0	*																	
Netherlands	50.0	49.2	17.4-29.7	36.6-47.6										58.4					32.0
Poland	50.0	28.0												50.0					
Portugal	39.4	44.0			44.0								22.0	44.0					22.0
Romania	40.0	25.0												25.0					25.0
Slovakia	50.0	25.0												60.0					
Slovenia	50.0	25.0												50.0					
Spain	50.0	40.0		6.4	40.0								40.0	28.0					28.0
Sweden	50.0	50.0	33.0	48-61	50.0									50.0					
United Kingdom	50.0	50.0												23.1					
Belarus	50.0	25.0																	
Croatia	50.0	25.0																	
Norway	50.0	50.0			50.0									52.8					
Russia	50.0	25.0																	
Switzerland	44.0	43.7								42.0	44.0	15.7					42.0	44.0	15.7
Turkey	50.0	*																	
Ukraine	50.0	25.0																	

Table 11. Nitrogen excretion coefficients for sheep and goat, as reported for Member States.

Country	GAINS	NIR 2011	NIR 2011	CAPRI	Nitrates Directive		Gothenborg								Eurostat/OECD												
	Sheep and goats	Sheep	Goat	Sheep and goats	Sheep	Goat	Sheep	Ewe	Sheep, meat	Sheep, milk	Sheep < 1 yr	Lambs	Goat	Does	Sheep	Goats	Total Sheep and Goats	Sheep and Lambs	Ewes and ewe-lambs put to the ram	Milk ewes and milk ewe-lambs put to the ram	Other ewes and ewe-lambs put to the ram	Other sheep	Lambs	Goats which have already kidded and goats mated	Goats which have already kidded	Goats mated for the first time	Other goats
Austria	13.0	13.1	12.3	5.2			13.1						12.3														
Belgium	7.4	7.5	8.4	5.5												13.1		14.0									
Walloon							8.8					4.4	8.8		8.9	8.3							4.8	9.6			4.4
Flanders					10.5	10.5	10.5					4.4	10.5		10.2	9.2							4.9	10.5			4.4
Bulgaria	12.0	14.7	17.0	9.5											7.4	7.1							4.6	8.0			4.4
Cyprus	12.0	*	*	9.2											14.7	17.0											
Czech Republic	12.0	20.0	25.0	4.7											9.5	11.2											
Denmark	17.0	15.3	16.4	8.8			17.0						16.3		9.8	9.8							5.1				
Estonia	14.0	16.0	25.0	6.5														17.0									
Finland	16.0	10.0	10.7	4.0			10.0						10.7		14.0	14.0			14.0			14.0		14.0			14.0
France	12.0	18.3	25.0	7.7												14.8		18.4									
Germany	7.5	7.4	11.0	5.0	18.1-18.6	14.8	7.8						11.0		10.0	10.7							8.9				
Greece	12.0	10.7	12.0	7.9											18.3	25.0											
Hungary	12.0	20.0	18.0	7.9																							
Ireland	8.0	6.3	9.0	5.1	7-13	9.0										14.6	15.7	15.8									
Italy	16.2	16.2	16.2	6.2			16.2						16.2		12.8	13.5							6.1				
Latvia	7.0	13.0	13.0	10.8											10.6	12.9											
Lithuania	12.0	16.0	16.0	6.7	12.0	10-12									16.0	16.0											
Luxembourg	12.0	17.0	17.0												17.0	17.0											
Malta	12.0	*	*	8.3											6.0	6.0											
Netherlands	11.5	6.7	9.9	4.8	7.4 - 10.2	3.1-5.8	14.1						17.5		9.1				9.1	9.1		9.1	9.1	9.1	9.1	9.1	9.1
Poland	13.7	6.8	6.7	6.2															14.4					16.0			
Portugal	7.0	7.1	6.0	8.4			6.6	9.2						7.0	8.0	7.0							6.0				
Romania	5.2	16.0	25.0	7.8															9.2			6.6		7.0			6.6
Slovakia	12.0	16.0	16.0	6.9											16.0	25.0											
Slovenia	11.3	20.0	25.0	5.0												10.0		10.0									
Spain	12.0	5.2	11.3	6.8	10.0	8.8	5.1						11.3		20.0									20.0			
Sweden	6.1	6.1	8.7	8.2	14.0		13.0								6.6	9.0	6.3	5.9					2.5		9.8	2.9	
United Kingdom	6.4	5.2	20.6	6.7											13.0	11.3											
Belarus	12.0	16.0	25.0																10.0			10.0	0.6	20.6			0.6
Croatia	12.0	16.0	25.0																								
Norway	14.7	10.4	15.5				11.6				7.7		15.5														
Russia	12.0	16.0	25.0												13.6	19.1							6.8				
Switzerland	8.2	8.5	10.2						15.0	21.0			16.0														
Turkey	12.0	13.5	16.5																21.0			12.0		16.0			
Ukraine	12.0	16.0	25.0																								

Table 12. Nitrogen excretion coefficients for fur animals and rabbits, as reported for Member States.

Country	GAINS	NIR 2011	Nitrates Directive	Gothenborg					Eurostat/OECD		
	Fur animals and rabbits	Fur animals and rabbits	Rabbit	Fur animals and rabbits	Rabbit	Mink and fitches	Foxes and racoon	Mink breeders	Rabbits	Fox	Mink
Austria	4.1										
Belgium	4.1								7.5		
Walloon									7.2		
Flanders			8.6		8.6				8.8		
Bulgaria	1.5										
Cyprus	4.1								5.0		
Czech Republic	1.5										
Denmark	4.6			5.3						12.6	5.0
Estonia	4.1										
Finland	1.9					1.3	2.3				
France	4.1									3.0	1.3
Germany	4.1		2.7-9.7								
Greece	4.1										
Hungary	4.1								5.5		
Ireland	4.1								1.0		
Italy	4.1			1.0							
Latvia	4.1										
Lithuania	4.1		2.5						8.1		
Luxembourg	4.1										
Malta	0.7										
Netherlands	2.2		0.5-1.53		7.7	2.2			7.9		2.4
Poland	4.1										
Portugal	0.7				9.0				9.0		
Romania	4.1										
Slovakia	4.1										
Slovenia	4.1										
Spain	1.5										
Sweden	4.1							4.1			
United Kingdom	4.1										
Belarus	1.5	4.6									
Croatia	4.1										
Norway	4.1	5.8					9	4.3			
Russia	4.1	4 -12									
Switzerland	4.1								9.0		
Turkey	1.5										
Ukraine	1.5	8.3									

2.4 Task 2. In-depth analyses of selected country reports

This paragraph provides a summary of the main findings of Task 2 'In-depth analyses of selected country reports'. The objectives of the in-depth analyses are:

- Further in-depth analysis of methodologies used for calculating and reporting excretion coefficients in ten countries, to be as selected jointly by the contractor and Eurostat.
- To identify differences in methodologies and give an overview of their complexity, strengths and weaknesses, spatial scale, and the data requirements.
- To point out the accuracy and reliability of the excretion coefficients in use in ten selected European countries.
- To compare the resulting excretion coefficients between the ten selected European countries and clarify differences.

The selected countries are Denmark, Estonia, France, Germany, Ireland, Italy, The Netherlands, Poland, Spain and the United Kingdom.

Categorization of farm animals

Total regional or national N and P excretions are calculated basically as the registered animal numbers times the average excretion per animal (kg/year). Here, animal numbers refer to the number of animals within specific categories of animals, and the average excretion per animal refers to the average per animal category. The regional or national N and P excretions are then calculated as the sum of the excretions of each animal category.

Comparing regional or national excretions is often difficult because of differences in the categorization of farm animals. For example, the animal weight classes or the animal age classes may differ between countries, and as a result the N and P excretions also differ. When the specification of the animal categories are known and data about animal number, animal feeding, animal composition, and N and P retention are known for each animal category, the N and P excretion can be assessed for each animal category. Animal categorization does not affect the number and type of the of building blocks needed for the estimation of N and P excretion.

Though animal categorization is not very relevant for the calculation of N and P excretions as such, it is highly relevant for the acquisition of data. The quality and accuracy of the collected data is the most important factor affecting the quality of the calculated excretion values; it depends on accessibility of information about animal numbers and information about the amount and composition of the animal feed and the nutrient retention by animal (i.e., animal productivity).

The availability of animal numbers per animal category is usually related to big changes in the animals life. This relates to for example pigs to the following events; birth, culling, rearing, fattening, and slaughtering. The age and/or weight at each event is rather well-known, but may differ per country or region due to differences in the dominant housing and/or feeding system. Hence, the highest quality of data about the age and weight of the animal categories, the feed intake and composition as well as the nutrient retention by the animal (animal productivity) are obtained when the animal categories reflect the local animal husbandry system. As a result, a uniform categorization of animals across EU-27, as in from example the Farm System Survey or Livestock registers, does make comparisons between regions and countries possible, but the quality of the data may be much less than in the case of a country-specific animal categorization.

Building blocks for the calculation of national excretions

National excretions in Member States are predominantly calculated by use of an input-output balance method. Input-output balances assume that the amount of nutrients excreted in faeces and urine is the total amount of consumed nutrients minus the nutrient content of products (milk, meat, eggs, live weight gain etc). For nitrogen (N), this may be represented as:
N excreted = N intake – N in products

Several calculation elements (building blocks) within the balance method can be distinguished. The information in building blocks is often calculated from other sources of information which are (sub)building blocks themselves. To distinguish between building blocks and sub building blocks levels of building blocks can be defined. Figure 1 shows the building blocks for the calculation of N and P excretion of a single animal.

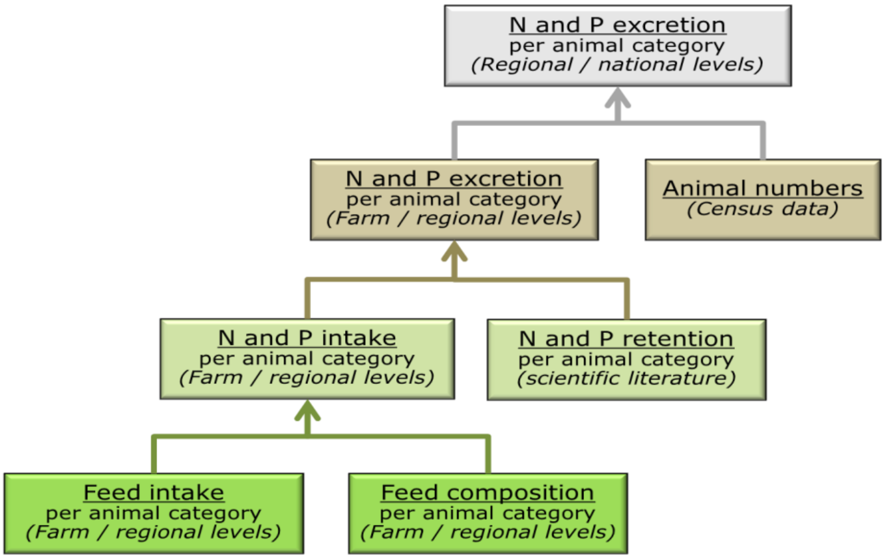

Figure 1. Building blocks for the calculation of N and P excretion per animal, in kg per animal per year.

Regional or national N and P excretions (kg N or P/year/national herd) at Tier 1 are calculated as registered animal numbers category and per region or country times the average N/P excretion per animal category per region or country (kg/year). The building blocks in this case are:

- Animal numbers per animal category
- Average N and P excretion per animal category (kg N or P/year)

The average N and P excretion per animal per year follows from data and information collected at Tier 2; it is calculated as: intake (kg/year) –retention (kg/year). The building blocks in this case are:

- Intake
  - Feed intake per animal (kg product or kg dry matter per year)
  - Feed composition (g N and g P per kg product or kg dry matter per feed)
- Retention
  - Growth, reproduction, milk, eggs and wool per animal (kg animal product)
  - Composition of growth, reproduction, milk, eggs and wool (g N and g P per kg animal product)

The N and P intake (kg/year) is calculated as: Feed intake (kg/year) x Feed composition (kg N or P/kg)
The N and P retention (kg/year) is calculated as: animal production (kg/year) x composition of animal production (kg N or P/kg)

Tier 3 is the basic level, where the data and information per animal category is collected. The nature of the data collected here differs between countries. Here, we briefly summarize the type of data and information used.

Feed intake per animal category:

- Non specific defaults from common literature
- Specific defaults from country or region specific feed tables
- Calculated feed intake derived from registered animal production and feed requirements
- Annual registered feed intake

Feed composition per animal category

- Non specific defaults from common literature
- Specific defaults from country or region specific feed tables
- Annual analyses of feeds and roughages

Animal production

- Non specific defaults from common literature
- Specific defaults from country or region specific data bases
- Annual registered animal production

Composition of animal production

- Non specific defaults from common literature
- Specific defaults from country or region specific experiments

Several data origins can be distinguished. Table 13 presents the lay-out of a classification scheme for assessing data origin and data quality. Five different data origins of decreasing quality (1 is the best) are distinguished. These five data origins have been combined with quality parameters as statistical reference and update interval. 'Statistical reference' is an abbreviation used for data that are based on a referred national inventory. The combination of 'update interval' and 'reference' can be scored as 1, 2, 3 and 4 for 'update interval' and Y or N for availability of a 'reference'. Table 13 presents example of assessments; all combination possibilities are considered. The format and over-all score of Table 13 is used for the in-depth analysis in the Task 2 report and further summarized in Table 14.

Table 13. Lay-out of the classification scheme for data origin and data quality; an example of an assessment.

Data origin	**Statistical reference**		**Update interval in years**				**Over-all**
			1	2-5	5-10	>10	**score**
	Yes	No					
1 Measurements input-output							
animal	x		x				1Y1
farm	x			x			1Y2
region	x				X		1Y3
country	x					x	1Y4
2 Modelling approach							
animal	x		x				2Y1
farm	x			x			2Y2
region		x	x				2N1
country		x		x			2N2
3 Measurements manure							
animal category		x	x				3N1
animal species		x		x			3N2
farm		x			X		3N3
country		x				x	3N4
4 Defaults							

animal category	x			x			4Y2
animal species	x				X		4Y3
common literature		x		x			4N2
country specific information		x			X		4N3
5 Expert judgement							
animal category	x				X		5Y3
animal species	x					x	5Y4
common literature		x			X		5N3
country specific information		x				x	5Y4

Comparison of data origin and data quality

A qualitative comparison of the methodologies used in the 10 countries is presented in Table 14. It shows that 8 out of 10 countries under consideration use the balance method (B). These 8 countries apparently have the infrastructure to collect information of the building blocks of the balance method. Poland and Estonia do not collect these data and rely on different methodologies to calculate excretions. As a result they have a lower score in the approach of Table 14.

Table 14. Overview of the assessment of data quality codes for ten EU countries. See Table 13 for the explanation of the codes; the first number refers to the data collection approach (1 to 5), the letter refers to the existence of a survey database (Yes or No), the final number refers to the actuality of the database (range 1-4).

Building block	**Country**									
	DK	**Fr**	**Ger**	**Irl**	**It**	**NL**	**UK**	**Esp**	**PL**	**Est**
N intake	2Y1	2Y1	2Y2	2Y1	2Y3	1Y1	2Y1	1Y1	5N4	5N1
N retention	2Y1	2Y1	2Y2	2Y1	2Y3	1Y1	2Y1	1Y1	5N3	5N3
Feed intake	2Y1	2Y1	2Y2	2Y1	2Y3	1Y1	2Y1	1Y1	4N3	5Y1
Feed composition	2Y1	2Y1	2Y2	2Y1	2Y3	1Y1	2Y1	1Y1	4N3	5N1
Animal production	2Y1	2Y1	2Y2	2Y1	2Y3	1Y1	2Y1	1Y1	4N3	3Y1
Animal composition	4Y1	1Y3	4Y2	4Y1	4N3	4Y2	4Y1	4Y2	4N3	5N3
Method used	B	B	B	B	B	B	B	B	SFOM	IPCC

Another way of presenting a qualitative assessment of the data quality is shown in Table 15; here the information from Table 14 was translated in qualitative parameters (+/-) to enable quick insight in data origin and data quality.

Table 15 Qualitative overview of data origin and data quality for ten EU countries; high quality is indicated by +++, low quality by --.

Building block	**Country**									
	DK	**Fr**	**Ger**	**Irl**	**It**	**NL**	**UK**	**Esp**	**PL**	**Est**
N intake	+++	+++	++	+++	++	+++	+++	+++	---	-
N retention	+++	+++	++	+++	++	+++	+++	+++	--	--
Feed intake	+++	+++	++	+++	++	+++	+++	+++	--	+
Feed composition	+++	+++	++	+++	++	+++	+++	+++	--	-
Animal production	+++	+++	++	+++	++	+++	+++	+++	--	++
Animal composition	++	++	+	++	--	+	++	+	--	--
Total	+	+	0	+	0	+	+	+	-	-
Method used	B	B	B	B	B	B	B	B	SFOM	IPCC

Executive summary of country information

In Germany, the N content of all categories of pigs is fixed at 25.6 g/kg (Table 16). For piglets and growing finishing pigs, this value is rather high compared to the values used in most of the other countries (France, Ireland, Italy, NL and UK). Values higher than 25.6 g/kg are used for 4-week old weaned piglets in Denmark and Ireland (30.4 g/kg) and boars in Ireland (27.4 g/kg) and growing finishing pigs in Denmark (29.6 g/kg).

For breeding sows, the 25.6 g/kg is also used in Ireland, the UK and Denmark (25.7 g/kg). Ireland, NL and the UK are using comparable values (24.8 – 25.0 g/kg) for the category of growing finishing pigs. In Italy, a little lower value (24.0 g/kg) is used for this type of pigs, whereas the value used in France (18.5 g/kg) is really out of range. The rather low N content in Italian growing finishing pigs might be related to a high fat content, because of the high slaughter weight (163.4 kg) of the Italian pigs. No explanation for the low N content in French growing finishing pigs is available.

In Germany, the P content of all categories of pigs is fixed on 5.1 g/kg (Table 17). In Ireland and the UK, comparable P contents (5.0 – 5.1 g/kg) are used for piglets and growing finishing pigs. In the Netherlands, the P content of all categories of pigs are in narrow range of 5.32 – 5.36 g/kg, accept for dead born piglets (6.15 g/kg). The P contents of pigs in Denmark ranged from 4.9 g/kg in weaned pigs to 6.0 g/kg in sows and boars. Compared to the contents in other countries, the Danish P contents for growing finishing pigs and breeding animals are high. In contrast, the French P contents for weaned piglets (4.0 g/kg) and growing finishing pigs (3.8 g/kg) are really out of range. No explanation for these low values is available.

The N and P contents of the different categories of pig diets are provided in Tables 18 and 19.

Table 16. N contents per category of pig (g/kg live weight) in different countries

Category	Estimated Weight kg)	Age/Physio-logical state	Denmark	Estonia[2]	France	Ireland	Italy	Germany	Netherlands	Poland[2]	Spain	UK
Dead born piglet	1.3	0 days	[1]	?	?	?	?	25.6	18.7	?	?	?
Culled piglet	2.8	1 – 28 days	[1]	?	?	?	?	25.6	23.1	?	?	?
Culled piglet	9.0	29 – 42 days	[1]	?	?	?	?	25.6	24.3	?	?	?
Weaned piglet	7.0	4 weeks	30.4	?	18.3	30.4	?	25.6	?	?	?	30.4
Weaned piglet	11.0	6 weeks	30.4	?	18.3	25.0	?	25.6	24.4	?	?	25.0
Culled piglet	12.0	7 weeks	30.4	?	18.3	?	?	25.6	24.5	?	?	?
Growing pig	26	10 weeks	29.6	?	18.5	25.0	24.0	25.6	24.8	?	?	25.0
Finishing pig	114	26 weeks	29.6	?	18.5	25.0	24.0	25.6	25.0	?	?	25.0
Rearing sow	125	7 months	25.7	?	?	22.0	?	25.6	24.9	?	?	22.0
Rearing sow	140	First mating	25.7	?	?	22.0	?	25.6	24.9	?	?	22.0
Rearing boar	135	7 months	25.7	?	?	27.4	?	25.6	24.9	?	?	27.4
Boar (breeding)	325	2 years	25.7	?	?	27.4	?	25.6	25.0	?	?	27.4
Breeding sow	220	At weaning	25.7	?	?	25.6	?	25.6	25.0	?	?	25.6
Sow at slaughter	220	1 wk after weaning	25.7	?	?	25.6	?	25.6	25.0	?	?	25.6

[1]) is settled with the sows.

[2]) Not relevant, because system is based on mineral excretion by manure.

Table 17. P contents per category of pig (g/kg live weight) in different countries

Category	Estimated Weight (kg)	Age/Physio-logical state	Denmark	Estonia	France	Ireland	Italy	Germany	Netherlands	Poland	Spain	UK
Dead born piglet	1.3	0 days	[1]	?	?	?	?	5.1	6.15	?	?	?
Culled piglet	2.8	1 – 28 days	[1]	?	?	?	?	5.1	5.36	?	?	?
Culled piglet	9.0	29 – 42 days	4.9	?	?	?	?	5.1	5.35	?	?	?
Weaned piglet	11.0	6 weeks	4.9	?	4.0	5.0	?	5.1	5.33	?	?	5.0
Culled piglet	12.0	7 weeks	4.9	?	4.0	5.0	?	5.1	5.33	?	?	5.0
Growing pig	26	10 weeks	5.5	?	3.8	5.0	?	5.1	5.32	?	?	5.0
Finishing pig	114	26 weeks	5.5	?	3.8	5.0	?	5.1	5.36	?	?	5.0
Rearing sow	125	7 months	6.0	?	?	?	?	5.1	5.35	?	?	?
Rearing sow	140	First mating	6.0	?	?	?	?	5.1	5.35	?	?	?
Rearing boar	135	7 months	6.0	?	?	?	?	5.1	5.35	?	?	?
Boar (breeding)	325	2 years	6.0	?	?	?	?	5.1	5.35	?	?	?
Breeding sow	220	At weaning	6.0	?	?	?	?	5.1	5.35	?	?	?
Sow at slaughter	220	1 wk after weaning	6.0	?	?	?	?	5.1	5.35	?	?	?

[1]) is settled with the sows.

[2]) Not relevant, because system is based on mineral excretion by manure.

Table 18. N contents per category of pig diets (g/kg) in different countries

Category	Denmark	Estonia	France	Germany[1]	Ireland	Italy	Netherlands	Poland	Spain[2]	UK
Starter diet weanling pigs	25.7	?	32.0-33.6	29.6	35.2	29.1	27.0	?	32.9	35.2
Grower diet weanling pigs (12-26 kg)		?	28.8-30.4	29.6	32.0		27.9	?	30.9	32.0
Starter diet growing finishing pigs (26–30 kg)		?	28.0	28.0-28.8	32.0	24.5	27.1	?	30.9	32.0
Grower diet growing finishing pigs (30–70 kg)	24.7	?	26.4	26.4 – 28.0	29.6		26.2	?	28.4	29.6
Finisher diet (70–114 kg)		?	24.0	22.4 – 23.2	27.2		23.6	?	26.7	27.2
Rearing sow diet (26–125 kg)	?	?	?	23.2 – 28.0	25.6	?	24.5	?	26.0-28.4	25.6
Standard sow diet	22.3	?	26.4	27.2	?	24.0	23.8	?	26.0-30.2	?
Lactating sow diet		?	26.4	28.0	27.2		24.5	?		27.2
Gestating sow diet		?	22.4	23.2	20.0		20.4	?		20.0

[1]) In Germany, standard and N-low diets are distinguished for growing finishing pigs and adjusted to growth rates of 700 or 800 g/d, resulting in ranges of N contents.

[2]) High value for in sow diets is related to high performing sows.

N contents of pig diets up to 30 kg are generally low in Denmark and the Netherlands, and rather high in Ireland/UK, whereas intermediate contents were reported in France, Germany, Italy and Spain. N-contents of pig diets from 30 kg to slaughter are low in Denmark, France, Germany (N-low diets), Italy and the Netherlands, and rather high in Ireland/UK and Spain. Danish sow diets contains the lowest N content, whereas the N content of sow diets are highest in Germany and Spain (high performing sows). The N contents of the sow diets in the other countries are in between.

Table 19. P contents per category of pig diets (g/kg) in different countries

<table>
<tr><th>Category</th><th>Denmark</th><th>Estonia</th><th>France</th><th>Germany</th><th>Ireland[1]</th><th>Italy</th><th>Netherlands</th><th>Poland</th><th>Spain</th><th>UK[1]</th></tr>
<tr><td>Starter diet weanling pigs</td><td rowspan="3">5.2</td><td>?</td><td>6.8-7.5</td><td>6.0</td><td>5.8-6.8</td><td>?</td><td>5.5</td><td>?</td><td>?</td><td>5.8-6.8</td></tr>
<tr><td>Grower diet weanling pigs (12-26 kg)</td><td>?</td><td>5.8-6.5</td><td>6.0</td><td>5.5-6.5</td><td>?</td><td>5.3</td><td>?</td><td>?</td><td>5.5-6.5</td></tr>
<tr><td>Starter diet growing finishing pigs (26–30 kg)</td><td>?</td><td>5.8</td><td>5.5</td><td>5.0-6.0</td><td>?</td><td>4.7</td><td>?</td><td>?</td><td>5.0-6.0</td></tr>
<tr><td>Grower diet growing finishing pigs (30–70 kg)</td><td rowspan="2">4.4</td><td>?</td><td>4.8</td><td>5.0-5.5</td><td rowspan="2">4.6-5.7</td><td>?</td><td>4.8</td><td>?</td><td>?</td><td rowspan="2">4.6-5.7</td></tr>
<tr><td>Finisher diet (70–114 kg)</td><td>?</td><td>4.4</td><td>4.5</td><td>?</td><td>4.6</td><td>?</td><td>?</td></tr>
<tr><td>Rearing sow diet (26–125 kg)</td><td rowspan="4">5.0</td><td>?</td><td>?</td><td>5.0-6.0</td><td>5.5-6.5</td><td>?</td><td>5.0</td><td>?</td><td>?</td><td>5.5-6.5</td></tr>
<tr><td>Standard sow diet</td><td>?</td><td>6.5</td><td>6.0</td><td>?</td><td>?</td><td>5.4</td><td>?</td><td>?</td><td>?</td></tr>
<tr><td>Lactating sow diet</td><td>?</td><td>6.0</td><td>5.5</td><td>5.8-6.8</td><td>?</td><td>5.7</td><td>?</td><td>?</td><td>5.8-6.8</td></tr>
<tr><td>Gestating sow diet</td><td>?</td><td>5.0</td><td>4.5</td><td>5.5-6.5</td><td>?</td><td>5.0</td><td>?</td><td>?</td><td>5.5-6.5</td></tr>
</table>

[1]) In Germany, standard and P-low diets are distinguished for growing finishing pigs and adjusted to growth rates of 700 or 800 g/d, resulting in ranges of P contents.

[1]) Low value refers to diets with phytase and high values to diets without phytase.

P content of diets of pigs up to 30 kg are low in the Netherlands and Ireland/UK, whereas P content of these diets are intermediate in Germany, and high in France and diets without phytase in Ireland/UK. In case of P-low diets (by use of phytase) P content of pig diets from 30 kg onwards are comparable between countries. Without phytase addition, the P content increases with 0.5 (Germany) to 1.1 (Ireland/UK) g/kg. Likewise, in case of P-low diets P content of sow diets are comparable between countries. Without phytase addition, the P content increases with 1.0 g/kg (Ireland/UK).

3 Identification of main 'building blocks'

3.1 Introduction

Within the DireDate project, a number of guiding principles for a "sustainable system of data collection and reporting" have been identified. These guiding principles have been used in the analyses of data needs for agro-environmental indicators and data collection. These six principles are:

(i) *Building block principle*, i.e., design the system 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 system has to be robust (sustainable) and flexible at the same time, to be able to adjust to future changes;

(ii) *Multiple solutions principle*, i.e., there is not just one optimal solution for deriving the system, but a range of possible solutions. Hence provide various proposals and indicate their pros and cons and 'margins of flexibility';

(iii) *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;

(iv) *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;

(v) *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.

(vi) *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?

This chapter deals with the identification of building blocks in the calculation of N and P excretion coefficients. Two types building blocks can be distinguished, namely those for (i) primary activity data and (ii) for coefficients (e.g. composition of animal products). Here, coefficients are defined as "factors or parameters which cannot 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 results of Tasks 1 and 2 have been used to identify the main building blocks for the calculation of N and P excretion.

3.2 Main building blocks

The building blocks depend on the methodology used for the calculation of N and P excretion. Roughly three methodologies for the estimation of N and P excretion and production are applied by Member States:

(i) default coefficients, based on literature studies and expert judgement,

(ii) input-output balance calculations, and

(iii) measurements of the volume and N and P contents of manure produced.

The most common method is the input-output balance calculation, which assumes that the amount of N and P excreted in faeces and urine is equal to the total amount of feed N and P consumed minus the N and P retained in marketed products (milk, meat, eggs, live weight gain), respectively. Hence, excretion = intake – retention. All methodologies allow in principle for making adjustment according to the length of the production cycle and for non-use of the stock accommodation, to provide an annual output factor per "animal place". The latter is necessary to allow for non-productive time needed for cleaning and re-stocking the housings.

Default coefficients

This is the most simple methodology, but yields the most uncertain (inaccurate) estimates of the N and P excretion. For this methodology, three building blocks can be distinguished:

- number of animals per animal category;
- default value for the N excretion per animal category; and
- default value for the P excretion per animal category.

The number of animals follow from census or surveys (primary activity data). The default values for the N and P excretion may follow from published reports or literature data (coefficients). Ultimately, the accuracy of the this methodology depends on how well the default values per animal category match the actual situation in practice.

Input-output balances

Figure 2 shows the main building blocks of the methodology based on input-output balance calculations. The input-output balance is a flexible method and provides also insight in the possibilities for management interventions to decrease N and P excretions.

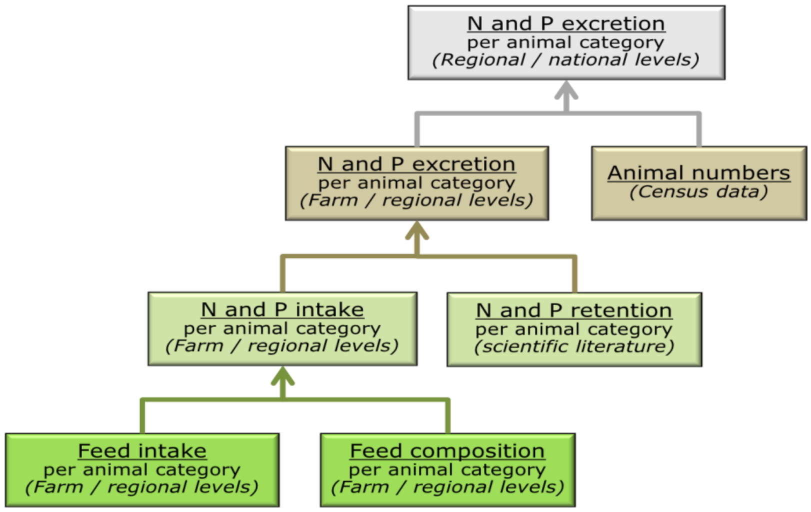

Figure 2. Flow of data and information for estimating N and P excretion at regional and national scales

For this methodology, the following five building blocks can be distinguished:

- Number of animals per animal category;
- N retention in animal products per animal category;
- P retention in animal products per animal category;
- Feed intake per animal category; and
- Feed composition per animal category.

The number of animals and feed composition follow from census or surveys (primary activity data). The N and P retention in animal products follow from published reports and literature data (coefficients), while the feed intake may either come from surveys (primary activity data) or from modelling exercises and literature data (hence, coefficients). Evidently, the 'building blocks' total N intake, total P intake, N excretion and P excretion (all per animal category) in Figure 2, simply follow from the processing of the aforementioned five basic building blocks.

Measurements of manure N and P produced

This method is used by some countries (see Table 4) for reporting about the progress of the implementation of the Nitrates Directive. It involves four building blocks:

- number of animals per animal category;
- volume of manure produced;
- N content of the manure; and
- P content of the manure.

The number of animals follow from census or surveys (primary activity data). The volume of the manure produced and the N and P contents of the manure either follow from direct measurements at farm level or from default values (published reports and literature).

4 Coherence in methodologies used

4.1 Introduction

One of the aims of Task 3 of the study ' Nitrogen and phosphorus excretion coefficients for livestock" (Lot 1 of Methodological studies in the field of Agro-Environmental Indicators; 2012/S 87-142068) is *'to analyse the coherence and differences of the methodologies used to estimate N and P excretions'* . The term "coherence' is perceived here as 'a systematic or logical connection' .

Roughly three methodologies for the estimation of N and P excretion and production are applied by Member States:

(i) default coefficients, based on literature studies and expert judgement,
(ii) input-output balance calculations, and
(iii) measurements of the volume and N and P contents of manure produced.

This paragraph briefly summarizes the 'coherences and differences of the methodologies estimate N and P excretions' .

4.2 Coherence in methodologies

An analyses of the UNFCCC national inventory reports 2011 shows that 10 Member States use the default IPPC values and that 17 Member States in the EU-27 use a country specific approach for N excretion estimates (

Table 2). The country-specific approach is commonly based on the input-output balance methodology. These 17 Member States in general use the same input-output balance methodology for the estimation of N excretion to be reported in the ammonia emission inventory (UNECE Gothenborg protocol). However, the N excretions reported within the framework of the greenhouse gas inventory and the ammonia emission inventory quite often differ for these 17 countries (Table 6). This indicates that applying the input-output balance methodology for different policy reports does not necessarily mean that the results are similar. Such differences may evolve from the use of different primary data or different coefficients or different data processing methods (order of calculations, different definitions of areas, etc).

Data origin is an important aspect in the estimation of N and P excretions. In Task 2, five different approaches for data collections were considered, as follows:
1 Measurements of inputs and outputs
2 Modeling approach
3 Measurements of manure only
4 Defaults
5 Expert judgment
It was suggested that the data quality decreases with the indicated order. Hence, highest data quality are obtained with measurement data, lowest quality data with defaults and expert judgment.

The aforementioned five approaches for data collection were judge further on the basis of survey data and the frequency of the surveys:

(i) The existence of a survey database at the applied scale (yes – no);
(ii) The time interval of revision / reconsidering the data (each yr, 2-5 yrs, 5-10 yrs, >10 yrs)

An assessment of (i) the data collection approach, (ii) the existence of a survey databases and (iii) the actuality of the database was made for all building blocks of the methodologies for estimation of N excretion in Member States (see also Chapter 3). The results of this assessment is presented in Table 14. It shows that simulation modeling is an essential element in the estimation of the building blocks N intake, N retention, feed intake, feed composition, and animal production. Interestingly, animal composition is commonly based on default values from literature, which are updated once in 2 to 5 yrs on average.

5 Comparability of reported coefficients

5.1 Introduction

One of the aims of Task 3 of the study ' Nitrogen and phosphorus excretion coefficients for livestock" (Lot 1 of Methodological studies in the field of Agro-Environmental Indicators; 2012/S 87-142068) is *'to analyse the comparability of the reported N and P flows, balances and emissions, both within countries and between countries, when using different methodologies for calculating excretion coefficients*.

This paragraph briefly summarizes the 'comparability of reported N and P excretions coefficients', based on the reports of Task 1 and 2 (see also Chapter 2 of this report).

5.2 Comparability of reported N and P flows and excretion coefficients

Tables 7 to 12 in paragraph 2 provide overviews of N and P excretion coefficients as reported by Member States, and Tables 16 to 19 provide overviews of various N and P coefficients used in the methodologies for the estimation of N and P excretions. Evidently, there are significant differences between countries but also differences within countries as regards reported N and P excretion coefficients. Also, there are differences between countries in N and P coefficients used in the methodologies for the estimation of N and P excretions.

Differences between countries in N and P excretion coefficients may relate to differences in animal breeds, animal performances, animal housing systems, animal feeding, feed composition and feed conversion. However, differences may also emanate from differences in methodology and data acquisition.

In general, the agreement between N excretion values reported for Member States are much larger for the policy reports (i.e., UNFCCC, UNECE/CLRTAP/Gothenburg protocol and Eurostat/OECD) than for the two modeling approaches analyzed in Task 1 (i.e., GAINS and CAPRI). However, the comparison is only partial, because the number of countries that report to the UNECE/CLRTAP/Gothenburg protocol is limited. Also, some Member States report national coefficients in one policy report and regionally-derived coefficients in another policy report.

The differences in the composition of animal products (N and P contents) may relate to (i) differences in animal breed, (ii) differences in weight and fat content of the animals (note, fat does not contain N and P, but also to actuality of the data. The latter is important, because the genetic potential of the animals and the feeding and housing systems change over time, and thereby also the N and P content of the animal products. As discussed also in the Task 2 report and in paragraph 2, some of the reported N and P contents of animal products seem outdated.

6 Best practices

6.1 Introduction

One of the objectives of this Task 3 study (see Chapter 1) is to identify best practices for calculating N and P excretion coefficients, on the basis of Tasks 1, 2 and 3. In general, 'best practices' are defined by

1. The objectives of the work undertaken;
2. The relative importance of the work;
3. The quality criteria defined for the work;
4. The conditions (e.g, availability of labour, time and financial means) of the work; and
5. The (technological, managerial) developments.

Hence, "best practices" are time and area dependent, they may evolve over time and vary from region to region, depending on conditions and relative importance. The first criterion indicates that 'best practices' are target oriented, i.e., depend on the objective of the work/study. The objectives indicate what needs to be achieved. The second criterion, the relative importance of the work, the task, the animal category, indicates how much means/efforts should be allocated to the work. The third criterion, the quality criteria used for the work, define the output in terms of accuracy and precision. The fourth criterion, the conditions, define how easily the targets/objectives can be achieved (and/or have to be adjusted). Finally, developments in science and technology occur almost continuously, and these developments must be considered when defining and revising 'best practices'.

Best practices for estimating N and P excretion coefficients is that the method and procedures are defined by the objectives and relative importance of nutrients in livestock excreta in general and/or for specific animal categories especially. Relatively large efforts should be given to important animal categories and no priority to small categories (in terms of total nutrient excretion). Hence, relatively large amounts of efforts (and means) should be allocated to relatively important (large) animal categories.

Best practices for estimating N and P excretion coefficients is in most cases using the balance method, i.e., nutrient excretion = feed nutrient intake – nutrient retention in animal products. The balance method follows from the basic law of mass conservation, from the first law of thermodynamics. This law describes a universal property on earth, also applicable to nutrient excretion calculations. However, for minor animal categories it may be good practice to use default values.

In theory, best practices mean that the procedures, methods, data sources, etc. have been clearly described in easy accessible reports and that quality criteria have been defined (in terms of sample sizes, accuracy, precision). Also, the methods have to be well described and certified, and institutions have to be qualified (accredited).

In practice though, there is little information in country reports about the consideration of best practices.

There are large differences between countries and the procedures and methods are not always clearly described, apart from reports prepared for the UNFCCC, in part because the guidelines of the UNFCCC provide clear best practice guidelines. Some countries have clearly described and detailed guidelines for estimating excretion coefficients (e.g., Denmark, UK, Norway, the Netherlands, etc., see chapter 2).

This chapter presents some general best practices for estimating N and P excretion coefficients, based on the draft reports of Tasks 1 and 2.

6.2 A three-tier approach as best practices

A three-tier approach describes three procedures for the estimation of N and P excretion coefficients, as function of the objectives of the study/work undertaken, the relative importance of the animal category, and the quality criteria and conditions (Figure 6.1). In all cases, a mass balance approach is applied for the derivation of the excretion coefficients per animal category, i.e.,

$$N_{excretion} = N_{intake} - N_{retention}.$$

$$P_{excretion} = P_{intake} - P_{retention}$$

where

$N_{excretion}$ and $P_{excretion}$ are the total N and P excretion (kg per animal per year), respectively,

N_{intake} and P_{intake} are the total N and P intake via animal feed (kg per animal per year), respectively,

$N_{retention}$ and $P_{retention}$ are the total amounts of N and P retained in milk, meat, egg, wool, etc., (kg per animal per year), respectively.

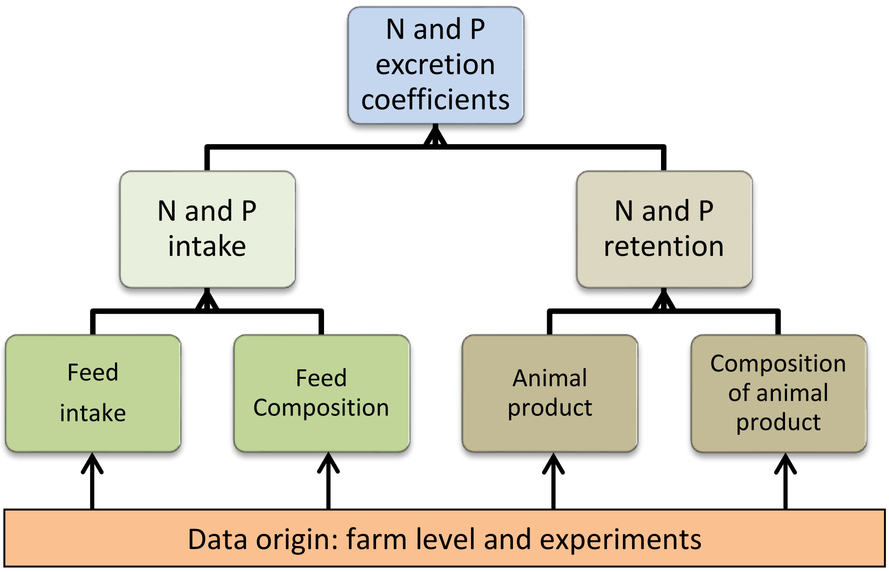

Figure 6.1 The three-tier approach for estimating N and P excretion (kg per animal category per year).

The Tier 1 approach is the most simple approach, with default excretion coefficients per animal category for the whole of EU-27. These default values should be evaluated and updated every 3 to 5 years. This approach may be used for "small animal categories" (i.e., small number of animals, with low N excretion per animal) and by countries with low data availability.

The Tier 2 approach applies country-specific default excretion coefficients per animal category. In case the regional variations in animal breeds, animal feeding, animal housing systems and animal productivity are large, region-specific excretion coefficients should be established per animal category. These country-specific and region-specific default values should be evaluated and updated also every 3 to 5 years. This approach may be used again for "small animal categories" (i.e., small number of animals, with low N excretion per animal) and by countries with a medium level of data availability.

The Tier 3 applies country-specific / region-specific and year-specific excretion coefficients per animal category. These specific excretion coefficients are derived on the basis of detailed information about animal breeds, animal feeding, animal housing systems and animal productivity. This approach should be used for "large animal categories" (i.e., large number of animals, with relatively large N excretion per animal) and by countries with relatively good data availability.

Tier 1

Tier 1 default values are used in case specific-country data about feed intake and composition, and animal production and the composition of the animal products are not easily available and the calculation of N and P excretions is not well possible. In that case default values have to be used. This may relate to regions and countries were the total N and P excretion of all animal categories is less than about 50 kg N and less than about 10 kg P per ha agricultural land per year. In case the total excretion is estimated to be larger than 50 kg N and larger than 10 kg P per ha agricultural land per year, it is recommended that countries invest in Tier 2 and 3 methods (and hence use country-specific, region-specific and/or year-specific excretion coefficients). Regions and countries with more than 50 kg N and more than 10 kg P per ha agricultural land per year may use default values for those animal categories that have a share in the total excretion within a region or country of less than 5 to 10%.

Default values have to be derived from peer-reviewed (inter)national literature and have to be elaborated and justified in terms of comparability as regards to animal categories, production levels, animal housing systems, feeding management and environmental conditions. Default values should be updated every 3 to 5 years on the basis of a review of the relevant data and literature and an examination of the animal husbandry practices, which must report on the technical progress in animal production. Preferably, the updated excretion coefficients are based on the estimated mean excretion coefficients during the last 3 to 5 years per animal category.

Evidently, when using Tier 1, variations between years in total excretions are caused by changes in animal numbers only (unless default values are updated).

Excretion of N (or P) is calculated as:

registered animal numbers x average N (or P) excretion coefficient per animal (kg/year).

The following data are needed:

- Animal numbers per category
- Average excretion coefficient per animal per category (kg N or P/year)

Tier 2

The Tier 2 methodology is applied when country-specific data are available to calculate mineral intake and mineral retention per animal category per year at regional level. Hence, at this level, the balance method can be applied at country or regional scale, but average values are used over periods of 3-5 years:

$$N_{excretion} = N_{intake} – N_{retention}.$$

$$P_{excretion} = P_{intake} – P_{retention}$$

This methodology is best practice for regions and countries with more than 50 kg N and more than 10 kg P per ha agricultural land per year. This methodology requires that feed balances can be made at regional (and national level) per animal category and that the N and P contents of the feed is known. Also, the methodology requires that the animal production and its composition in terms of N and P are known, and based on 3 to 5 years data.

For this methodology, the following five building blocks can be distinguished:

- Number of animals per animal category;
- N retention in animal products per animal category;
- P retention in animal products per animal category;
- Feed intake per animal category; and
- Feed composition per animal category.

The number of animals and feed composition follow from census or surveys (primary activity data). The N and P retention in animal products follow from statistics of animal production (milk, meat, egg, animals), and from published reports and literature data (N and P contents in animal products. The feed intake follows from the statistics and calculations about feed consumption per animal category and from analysis data about the N and P composition of the feed ingredients. Based on these data, the 'building blocks' total N intake, total P intake, N retention and P retention per animal category in Figure 6.1 can be calculated and hence, N excretion and P excretion per animal category.

In summary,

Total N (or P) excretion = registered animal numbers x N (or P) excretion per animal (kg/year)

N (or P) excretion per animal = N (or P) intake – N (or P) retention (all kg/year)

- N (or P) intake requires information about:
  - Feed intake per animal (kg product or kg dry matter per year)
  - Feed composition (g N and g P per kg product or kg dry matter per feed)
- N (or P) retention requires information about:
  - Growth, reproduction, milk, eggs and wool per animal (kg animal product)
  - Composition of growth, reproduction, milk, eggs and wool (g N and g P per kg animal product)

Tier 3

At Tier 3 all data for the basic building blocks (feed intake, feed composition, animal production and composition of animal products) are available on an annual basis.

Tier 3 is the most basic level; it results in region-specific and year-specific N and P excretion coefficients. This methodology is especially recommended for countries that have an estimated excretion of more than 200 kg N and more than 30 kg P per ha agricultural land per year. These threshold values are derived from the EU 1991 Nitrates Directive (200 kg N per ha in animal excrements corrected for 15% gaseous N losses from stables and manure storages results in 170 kg of N in the manure that is available for application to land), and from the estimated mean P withdrawal with harvested forage crops in most EU countries. Hence, farms producing more manure N and P than these threshold values may have to export animal manure to other farms, and/or require a derogation from the obligations of the EU-Nitrates Directive to be able to apply more than 170 kg manure N per ha agricultural land.

At Tier 3 data are available to calculate mineral intake and mineral retention per animal category per year per region. Also here, the balance method have to be applied:

Excretion of N (and P) = Intake of (and P) minus retention of N (and P).

For this methodology, the following five building blocks can be distinguished again:

- Number of animals per animal category;
- N retention in animal products per animal category;
- P retention in animal products per animal category;
- Feed intake per animal category; and
- Feed composition per animal category.

Currently, this methodology is used also on intensive livestock farms and dairy farms in Denmark and The Netherlands. Special computer programs have been developed that facilitate the calculation of farm-specific N and P excretion coefficients and total N and P excretion at farm level.

The following data are needed:

N and P intake:

- Calculated feed intake derived from registered animal production and feed requirements
- Annual registered feed intake, from among other certified feed companies
- Specific defaults from country or region specific feed tables
- Analyses of feeds and roughages
- Analyses of purchased feeds

N and P retention

- Annual registered animal production (export of meat, milk, egg, animals)
- Specific defaults values about the composition of the animal products, from country or region specific experiments

6.3 Best practices for data collection

The three Tiers discussion in section 6.2 can be used as three different methods to estimate the total annual N and P excretions per animal category per country. The accuracy of the calculated N and P excretions will vary with the Tier chosen, due to differences in the origin and quality of the data.

To calculate N and P excretion on a national level, several data origins can be distinguished (see chapter 3). Table 3 shows the recommended data origins for the three Tier levels discussed in paragraph 6.2. Statistical reference is used as an abbreviation for data that are based on a referred national inventory.

Best practices for data collection must account for differences between countries in the importance of livestock production (livestock density, total N and P excretion) and of data availability. For regions and countries with a relatively high livestock density and hence large N and P excretion it is recommended to use Tier 3 (at regional level) or perhaps Tier 2 approaches. Best practice for regions and countries with a relatively low livestock density and hence low N and P excretion and also low data availability is using a Tier 2 approach for the largest animal categories (in terms of numbers and N and P excretion per animal, and a Tier 1 approach for all other animal categories. Note, that a Tier 3 methodology will be needed once in 2 to 5 years, to derive the N and P excretion coefficients needed for the Tier 2 level.

For Tier 3, a combination is needed of (i) data statistics and surveys (animal numbers per category, amount and composition of purchased feed, and amount and composition of sold animal products), (ii) measurements (amounts and composition of farm-grown feed), and (iii) modelling (animal feed requirements per animal category). Computer programs should be made to allow the calculation of the N and P excretion per animal category at regional levels. Best practice is that these estimations are made on an annual basis and that the number of animals, the amount and composition of purchased feeds, the amounts and composition of farm-grown feeds, and the amount of sold animal products are quantified on an annual basis, using certified computer procedures (programs) and accredited laboratories. The composition of the animal products are less variable and should be measured only once in 5 to 10 yrs.

For Tier 2, again a combination is needed of (i) data statistics and surveys (animal numbers per category) and N and P excretion coefficients. These N and P excretion coefficients have to be updated every 2 to 5 years, using a Tier 3 methodology. Best practice is also that these revised N and P excretion coefficients are based on analyses of the amounts and composition of purchased feeds, the amounts and composition of farm-grown feeds, and the amount of sold animal products using certified computer procedures (programs) and accredited laboratories. The composition of the animal products are less variable and should be measured only once in 5 to 10 yrs.

For Tier 1, simple default values are needed. Best practice is that these default values are reviewed and up-dated once in 3-5 yrs, again through the use of a Tier 3 methodology at the level of the EU-27.

Table 3. Best practices for data origin of the building blocks of the Tier 1, 2 and 3 methodologies.

Tier level and building blocks	**Statistical reference**		**Literature**		**Update interval, years**		
	Yes	No	National	Inter-national	1	2-5	5-10
Tier 1 Default values for EU							
Animal number per animal category	X					X	
N & P excretion coefficients		X		X		X	
N & P intake		X		X		X	
N & P retention		X		X		X	
Tier 2 Region-specific values							
Animal number per animal category	X					X	
N & P excretion coefficients		X	X			X	
N & P intake		X	X			X	
N & P retention		X	X			X	
Tier 3 Region & year specific values							
Animal number per animal category	X				X		
N & P excretion coefficients		X	X		X		
N & P intake		X	X		X		
N & P retention		X	X		X		
Feed intake	X				X		
N & P contents of the feed		X	X		X		
Animal production	X				X		
N & P contents of the animal products		X	X				X

7 Conclusions and recommendations

The main objectives of this task were:

- To analyse the coherence and differences of the methodologies used to estimate N and P excretions;
- To identify the main components (building blocks) of the methodologies
- To analyse the comparability of the reported N and P flows, balances and emissions, both within countries and between countries, when using different methodologies for calculating excretion coefficients;
- To identify best practices for calculating N and P excretion coefficients.

The main conclusions of this task are:

- The methodologies and procedures used by Member States for estimating N and P excretion coefficients per animal category are often not well described.
- Reported N and P excretion coefficients per animal category by Member States may differ significantly between Member States. The difference between these coefficients are not always clear and seem not always plausible
- Reported N and P excretion coefficients per animal category by Member States may differ between policy reports for one and the same Member State. The difference between these coefficients are not always clear and seem not always plausible.
- The mass balance approach, i.e., Nutrient excretion = nutrient intake via feed – nutrient retention/retention in animal products is a basis for most of the used methodologies.

The main recommendations of this task are:

- The methodologies and procedures for estimating N and P excretion coefficients per animal category, as used by Member States, should be clearly described, reviewed and regularly updated, when needed.
- A three-tier approach for the estimation of N and P excretion coefficients, as function of the objectives of the work, relative importance of the animal category, quality criteria and conditions should be uniformly adopted by Member States in the EU-27. This approach is rather similar to the approach applied by the UNFCCC for reporting greenhouse gas emissions from animal manure management, as well as the approach recommended for the Nitrates Directive (ERM, 1999).