Soil Nutrient Balances

Reviewing and Developing to Meet Customer Needs

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Executive Summary

Approach/methodology

- The Gross Nutrient Balance (GNB) approach is a generally sound method of estimating overall environmental pressures from nutrient loadings to agricultural soils.
- The current methodology does not consider loss pathways, how the nutrient loadings are lost from the soil and whether, for example, they impact on air quality or water quality.
- The balances provide an estimate of total annual loadings but do not attempt to quantify the cumulative or long term impacts of these annual loadings.
- The GNB approach does not take into account factors that affect nutrient levels such as animal housing systems, feed regimes and methods of applying manures. As these are likely to be the areas where policies can have an impact, the nutrient balances could be described as not being sufficiently policy sensitive.
- There is considerable scope to link the nutrient balances with a range of work in related areas. This would allow a more efficient use of the source data that is common to each system and help ensure consistency.
- The main areas/systems that are linked to nutrient balances are:
    - greenhouse gas emissions inventory
    - national Nitrogen and Ammonia budgets
    - use of manures in biogas and anaerobic digestion
    - use of agricultural soils as a sink for sewage sludge

Data issues

- Balance sheets are a complex system with a number of data sources.
- At a national level, most of the data is from reliable and well-established data sources.
- Data sources need to be carefully checked: balance sheet systems and results should be subject to thorough review every few years.
- Coefficients represent an unusual form of official statistic, requiring careful management and documentation. The UK supports the proposal by Eurostat to set up a library of coefficients.

Quality of specific data components

- Estimates for offtake from pasture are based on average pasture yields and an assumed rate of grazing. Pasture represents a very significant part of the overall offtake and improvements in these estimates would greatly improve the overall accuracy of the balance sheets.
- Estimates of fertiliser use at below national level are based on a national average application rate for each crop type. Due to regional variation in practice, estimates would be improved if regional level application rates for each crop type could be estimated from the British Survey of Fertiliser Practice.
- The land to be used in the scope of the balance sheets must be correctly defined. If unfertilised land is included, the balance sheets will underestimate the total nutrient loadings. Reflecting this, the UK excluded land identified as “rough grazing” from the balance sheets.

- Manure is assumed to be applied to the same parcel of land on which the livestock are grazed/reared. This assumption is robust at aggregated levels but may not be valid at finer spatial scales, particularly at a holding level.

Geographic scale

- The reliability of the data sources, and therefore of the balance sheet estimates reduces, the finer the geographic scale.
- At national level the results are fairly robust. The coefficients will represent average values across all regions and errors introduced by random variation should to a large extent cancel out.
- At NUTS1 level, the estimates are less reliable but still provide a broad indication of nutrient pressures and allow comparison between regions.
- At NUTS3 level the GNB approach is too simplistic to provide robust estimates of actual loadings.
- NUTS3 results can best be presented as a map or change matrix
- NUTS3 maps should use large size bands to reflect the large confidence intervals for the estimates. Descriptive terms could be used for the size bands (e.g. low risk) rather than exact ranges (e.g. 50 to 100 kg/ha). This will reduce the risk of over-interpretation by data users.
- More process-based models populated by purposely collected data need to be used at finer scales (e.g. catchments).
- NUTS2 might represent a useful scale at which to produce balance sheet estimates. However, standard statistical outputs are not currently produced at NUTS2 in the UK.

1. Introduction/background to nutrient balances

The methodology that forms the basis for this project is the standard approach developed by OECD and adopted by Eurostat. Details of the system are contained in the OECD/Eurostat Handbook[1]

The OECD system calculates nutrient loadings for nitrogen and phosphorus to agricultural soils. It is a fairly complex system based on wide range of data sources. Nutrient inputs and off-takes are estimated by applying coefficients to physical data. The physical data covers livestock numbers, crop areas, crop yields and fertiliser use. The relevant coefficients have been developed by empirical research by experts (e.g. ADAS) within a large programme of research projects.

Annex 1 provides a flow chart to summarise how the various data sources are brought together and the balance calculated.

The nutrient balances represent a generic analytical tool relevant to air quality, nutrient management, water quality, and greenhouse gas contribution to climate change. The overall balance (kg of N per ha) gives a useful headline figure of potential environmental pressure. This can be used as a high level indicator, allowing trends over time to be monitored and comparisons to be made between countries.

Nutrient balances are of direct relevance to a number of European directives including the Air Quality Directive [2], the Water Framework Directive[3] and the Habitats Directive[4]. Nutrient balances are therefore an important part of the evidence base to a number of European and international organisations including Eurostat, DG AGRI and DG Environment and the European Environment Agency.

One of the agri-environment indicators developed under the IRENA program, 18.1, is on gross nitrogen balances. The indicator fact sheet identifies links with a number of other IRENA indicators:

Input indicator links:

- IRENA 08 - Mineral fertiliser consumption
- IRENA 13 - Cropping/livestock patterns
- IRENA 14 - Farm management practices

Output indicator links:

- IRENA 18sub - Ammonia emissions
- IRENA 19 - Emissions of methane and nitrous oxide
- IRENA 30 - Nitrates/pesticides in water
  IRENA 34.2 - Share of agriculture in nitrate contamination

[1] OECD/Eurostat Gross Nitrogen Balances Handbook, December 2003

[2] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

[3] 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy

[4] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

2. Evaluation of Gross Nutrient Balance approach

2.1 Understanding the policy needs for Gross Nutrient Balances

The nutrient loadings on agricultural soils represent a serious potential environmental threat. There are a number of possible pathways by which the nutrients can be lost from the soil. Each of these loss pathways can lead to a different environmental problem.

A standard unit of measurement across all policy areas

A key benefit of the nutrient balance approach is that it provides a single common unit to measure environmental pressure that is relevant to all policy areas. This benefit should not be underestimated. Where policy responsibility is split between different areas there is always a risk of tensions between different policies and an improvement in one area may come at the cost of another area. By ensuring a common unit of measurement is used across air and water quality it should be possible to develop coherent policies based on a net improvement in the full range of impacts.

Environmentally relevant geographic units

One of the key issues that emerged from consultation is the need for environmentally relevant geographic units for calculating nutrient balances. The NUTS nomenclature is based on administrative boundaries that have limited relevance to agriculture or the environment; consequently these geographic units are not the most useful for agri-environment policies. The most appropriate geographic unit will vary depending on the specific policy area.

- For river water quality, river catchments and Nitrate Vulnerable Zones offer the most relevant units.
- For air quality, ammonia emissions are of greatest concern for their potential impact on sensitive habitats, causing eutrophication as a result of nitrogen deposition. The UK has developed a classification system known as National Character Areas[5] that would provide suitable geographic units

Agriculturally relevant units

There is also much value in using agriculturally relevant units. Farm level balances will always be challenging to estimate because of the large number of data items required. Geographic units are less directly relevant because the nutrient balance for a given area reflects the type of farming activity taking place rather than any inherent spatial property of that area. Therefore, calculating estimates by farm sector would be more policy-relevant in terms of targeting measures at improving farming systems.

Meeting specific policy needs and timescales

When considering policy needs for data, it is important to balance the amount of resource required to produce data with its value. Data must be fit for purpose by meeting a number of quality criteria including reliability and timeliness. Given the significant resources required to produce a full set of nutrient balances at a fine spatial scale there may be scope to tailor the specific nutrient balances outputs to meet specific data needs at a particular point in time. For example a full set of results at a fine spatial scale could be produced every few years to provide a baseline or for monitoring at key milestones such as the deadline for a Framework Directive. For less policy critical intervening years a

[5] http://www.naturalengland.org.uk/ourwork/landscape/englands/character/areas/default.aspx

simplified approach could be adopted or results could be produced only at a more aggregated geographic level.

To be used as part of the evidence base for developing and monitoring agri-environment policy the nutrient balances should be sensitive to the very policies whose impacts they are measuring. For example, if a policy is introduced to change housing systems to reduce the loss of ammonia, it must be possible to monitor the impacts of that policy in order to gauge its effectiveness. It is a key weakness of the current nutrient balances approach that most of the farm practices that have significant impacts are not reflected in either the data or coefficients used in the balance calculation. Indeed, there is a dearth of statistical information about these, making it impossible to incorporate them using current data sources.

Presentation and interpretation

For policy customers to make the best use of nutrient balances, consideration needs to be given to issues of presentation and interpretation. At a national level, the overall balance figure provides an indicator which can be presented in a chart as a time series to show state and trend, both long- and short-term.

NUTS 1 balances can be shown as a table, a series of charts or using maps. There is limited value in mapping at Member State scale given the relatively low number of data points, although at EU scale such maps would have value.

At NUTS3 level a map is almost essential to present the results. With over 100 data points in the UK it is not possible easily to show overall results or trends using charts or tables, whereas a map can clearly show key trends and important geographic patterns.

Whilst the main policy interest may be in the overall balance, individual components of the balance sheet may also be of value, particularly in specific policy areas. For example the nutrient inputs from cattle manure would be directly relevant to policies aimed at reducing diffuse water pollution from dairy farms.

Another valuable role for the nutrient balance system is in scenario modelling. Key data items can be adjusted to answer "what if" questions, for example, what would be the impact of a 50% decline in dairy farming in the South West.

2.2 Evaluating the OECD Gross Nutrient Balance approach

The nutrient balances represent a generic analytical tool relevant to air quality, nutrient management, water quality, and greenhouse gas contribution to climate change. Were they an accurate measure of the true levels, the overall balance (kg of N per ha) would give a useful estimate of overall environmental pressure. This could be used as a high level indicator, allowing trends over time to be monitored and comparisons to be made between countries.

There are several other systems and models that have been developed for nutrient management. These generally focus on answering more specific policy questions. Compared to these systems, the GNB approach has both strengths and weaknesses.

2.2.1 Strengths

Robust and reliable approach

The overall GNB approach is in principle conceptually and methodologically sound. It is largely underpinned by reliable and established data such as livestock numbers and crop areas which are collected according to standards laid out by Eurostat.

A generic and flexible measure

The overall balance provides a high level pressure-type measure that can be relevant to a wide range of policy contexts.

Open and transparent

Although a number of calculations are performed on a large volume of data, it is straightforward to see what data is used and how the calculations are done. There are likely to be clear relationships between trends in the overall balances and the most influential source data – for example an increase in surplus might be traced back to a corresponding increase in livestock numbers. Correspondingly, changes that are locally significant may be obscured by more dominant data.

Impartiality and integrity

Due to a combination of other factors described in this section, the GNBs have the advantage of being produced with impartiality and integrity, key qualities for official statistics. They are not susceptible to interference from, for example, political expediency. Assuming a consistent approach can be assured, there is also limited scope for subjectivity in their interpretation.

Easy to interpret

The overall balance is a simple, single value expressed as a loading per unit area, in kilogrammes per hectare. In terms of level of measurement, it is a ratio measurement on a continuous (rather than discrete) scale and has a non-arbitrary zero. Differences and ratios between arbitrary pairs are meaningful. This gives the balance some very useful properties when comparing one unit with another or a change over time for a given unit. For example an increase from 20 kg/ha to 40 kg/ha can be meaningfully compared with an increase from 50 kg/ha to 70 kg/ha (same absolute increase) or from 50 kg/ha to 100 kg/ha (same percentage increase).

In keeping with a desirable criterion for any indicator, the GNB is simple to interpret in terms of whether things may be improving or getting worse.

Allows benchmarking between units/countries

By taking a standard and consistent approach, meaningful comparisons can be made between units (regions) and between countries.

Time series data available

Data sources for the balances are well established so historic data is generally readily available on a consistent basis for the UK. This allows a consistent time series to be produced to allow analysis of trends over time.

2.2.2 Weaknesses

Large volume of data and processing

Compared with most official statistics the system requires a large volume of data to be brought together from a diverse range of sources. Processing is mathematically simple but takes place on a large scale so care is needed to be accurate.

Data sources

Reliability of the data varies between the different sources. For some data sources, national level estimates are reliable but become unreliable at finer spatial scales (crop production for minor crops). For other data sources there are breaks in the time series (cattle numbers).

Coefficients

The input and offtake coefficients are quite different to most sources of official statistics. They are derived from empirical research and their provenance can be hard to determine and document. Improvements in the estimates of coefficients generally require applying retrospective revisions to historic data to produce a consistent time series. The proposal by Eurostat to develop and maintain a library for the coefficients for all Member States would be advantageous in this respect.

Needs clear co-ordination and single provider

The complexity and range of data sources create scope for inconsistencies if the balance sheets are produced by different institutions. To avoid this Defra should take the lead in the UK and act as a single authority in developing and maintain the system and its outputs.

Large error margins

The physical data and coefficients have error margins that introduce fairly large confidence intervals around the estimates. This is particularly an issue at a fine spatial scale because the precision of data is reduced for small area estimates, and the coefficients are estimated at national scale and often will not reflect local conditions. As a result, care is needed in policy interpretation and decision making.

Lack of flexibility

In some areas the current system can be considered too prescriptive. Where coefficients are applied to physical data there should be flexibility to use whichever categories can be supported by the most reliable data. Livestock categories, for example, do not need to be identical for every country. As long as there is consistency to how the coefficients are applied to matched physical data the balance estimates will be consistent and comparable.

Lack of focus

The generic and flexible nature of the balances can also be a limitation. It provides less relevant and specific data for particular policy purposes. This is reflected in the fact that policy areas have sponsored more elaborate and focussed tools in the form of complex models and databases. These tools provide answers to much more specific policy questions and can include a range of other factors such as financial costs to farmers.

No estimate of loss pathways

Nitrogen surpluses can be lost to air or water and can impact on air quality, water quality, and damage sensitive habitats from nitrogen deposition and acidification. However, the GNB approach does not provide any estimation of these loss pathways or eventual impacts. The assessment of loss pathways is a separate issue both in data requirements and conceptually. Estimating losses requires data on a wide range of issues on farm practices and soil management as well as environmental data such as weather, topography and hydrology. There is currently little data available on some of these factors in the UK.

The main farm practices and other factors not taken into account by the current approach are:

- Livestock breeds
- Feed regimes
- Housing systems
- Slurry storage systems
- Manure and fertiliser spreading - methods, timings in relation to weather

No assessment/interpretation of cumulative effects

The GNBs provide an annual estimate of total nutrient loadings but one of the key environmental issues is the long term impact on nutrient levels and the cumulative effects of a surplus over many years.

3.2. Data issues

3.2.1. Physical data

The system relies on bringing together a large volume of physical data, summarised below:-

- Livestock numbers by category (head)
- Crops areas by category (ha)
- Crop production estimates (tonnes)
- Fertiliser use (tonnes)
- Land use (ha)
- Disposal of sewage sludge on farmland (tonnes)

Many of these data items are collected from annual surveys run, or managed, by Defra; the latest quality assured data have been used in the calculation of time series of balances reported here.

Crop area data

Reliable estimates of crop and livestock data come from the Farm Structure Survey and represent an annual snapshot from June each year. Data is available at a holding level. Data is also available from a survey in December but this offers no additional benefits because it only provides another snapshot at a different point in time and is based on a smaller sample size.

Crop production data

Figures are based on area, yield and production estimates submitted to Eurostat each year. For the main crops, these figures are collected from a sample survey and are reliable at NUTS1 level. For minor crops, estimates are only reliable at a national level. Generally speaking, estimates for minor crops at a finer spatial scale will be self-correcting due to the dominance of production in key areas. The overall yield for a crop will be mainly determined by the yields achieved in the regions where production is highest. Regions where production is low may have inputs and/or yields that deviate from the average but the low levels of production mean that this has little impact on the overall balance estimates.

Livestock data

Reliable estimates of crop and livestock data come from the Farm Structure Survey and represent an annual snapshot from June each year. Data is available at a holding level. As with crop areas, data is also available from a survey in December but this offers no additional benefits. Population profile data has been available since 2005 for cattle, taken from the Cattle Tracing Scheme.

Policy interest is in the total loading from nutrients over the course of a year, including whether there are any peak loadings, for example at a given point in the growing cycle for crops. Population profile data would, in theory, provide useful additional data on variations throughout the year. However, the current methodology is not sophisticated enough to take such variations over the year into account. In effect it uses average estimates for every parameter and assumes the loading is distributed evenly throughout the whole year. Given the limitations of the current approach, profile data will give only slightly improved estimates of an annual total where production cycles are annual and changes in livestock numbers follow a regular pattern. The potential benefits of this type of data are greater in the event of external shocks such as disease outbreaks.

Matching data categories

The categories used within the nutrient balances system are not always consistent with those for which physical data are available. This is particularly an issue for livestock data. Where there is not a direct match, the best possible match must be made, thereby introducing a degree of approximation.

A possible solution to this problem would be for the nutrient balance sheet categories to be based on the categories in the FSS. In the longer term, one possible approach would be for FSS data to be collected using the nutrient balances categories, reflecting the growing importance of environmentally relevant data and the diminishing importance of market management data needs. This would of course lead to a loss of comparability with earlier data and a break in the time series.

Offtake from pasture/fodder production data

Estimates of offtake from pasture are currently very crude. These apply an average pasture yield (of 8t/ha) to both permanent and temporary pasture to estimate a production figure. This yield is assumed constant for all years, although this is very unlikely to be realistic in view of annual variation in weather. This is then adjusted by a "utilization" factor to reflect the fact that not all pasture is grazed due to "wastage" and where grass is removed for conservation (hay or silage). Wastage is caused by treading, poaching and fouling of grass during grazing. Based on expert opinion an overall figure of 70% has been used for UK estimates for both temporary and permanent pasture. Recent expert opinion suggests more accurate estimates of utilization rates are nearer 75% for permanent grass and 85% for temporary grass but these need to be assessed before they are adopted.

One approach to estimating fodder production is to use a feed balance. This is based on a model which assumes:-

(a) Meat/milk production $\propto$ *(b) fodder + (c) feed*

If we were to have reliable estimates of total meat and milk production and animal feed in the form of compounds and hay and silage it would be possible to estimate the fodder component.

The yield and grazing proportion are both constant for all years and an average value is used for all regions and countries. There is likely to be annual variation plus significant regional variation in yields which is not currently accounted for because a national average yield is used.

Recommendations for improving the quality of the offtake from pasture are given in section *10.1 Improved estimates*

Fertiliser use data

Reliable estimates of fertiliser usage are available at a country level from the British Survey of Fertiliser Practice[6]. Estimates are also available at a NUTS1 level but these are derived by applying average application rates for specific crops to NUTS1 data on crop areas. This approach provides reliable estimates at fairly coarse spatial scales but not at fine spatial scales. Further work will be done outside the scope of this project to improve estimates at a finer spatial scale.

Gaseous emissions during housing

Losses of N will take place during livestock housing and storage of manures through volatilisation and denitrification. Some of this loss may ultimately return to agricultural soils through N deposition. As the GNB approach is a soil balance, any gaseous losses during housing are not accounted for. The approach requires that atmospheric deposition is only from non-agricultural sources. If gaseous emissions during housing/storage could be estimated, this particular loss pathway could be included in the balance sheet. It would then need to be accounted for elsewhere in the balance sheet by including agricultural sources of atmospheric deposition. In effect this can be seen as a double-entry on the nutrient budget which makes no overall difference but provides a useful estimate of a specific loss pathway.

Nutrient input from manures

Nutrient inputs from manures will reach the soils via two routes. The direct route is when manure is voided by animals *in situ* whilst grazing. The second route is where manure and slurry is collected in housing systems and subsequently spread on the land. The OECD method assumes that all nutrients from livestock are input onto the land where those animals are reared. This assumption is sound for voided manure. Where livestock are housed, there may be movement of the manure off farm or from one farm to another. Statistical estimates for movement off farm are available only where the manure is used for combustion to produce power. No estimates are available for movement between farms but there is good anecdotal evidence that this does not take place over large distances or on a large scale because of the low monetary value of manure. This assumption is felt to be sound, particularly at a gross spatial level. At fine spatial scales (e.g. holding level or 10km grid) however, this assumption may not be tenable and may introduce quite significant errors into the calculations.

Accurately defining the scope of the balance sheets

As the OECD handbook identifies, "the balance sheet result should be related to the area of agricultural land which is potentially fertilised, to avoid a bias in the result for countries with large extensive and not utilized areas". In theory defining the scope of the balance sheet should be straightforward but in practice this is not so straightforward due to the limitations of the available data.

What is required is a standard criterion for defining fertilised land, which is to be in scope for the balance sheet. Ideally, this criterion could be applied in a consistent way across all countries. Secondly, having defined the land in scope, it is necessary to identify those livestock that are reared on that land.

Various approaches to this were considered in this study, the most realistic options identified were:-

- All agricultural land
- Exclude land in Less Favoured Areas (LFA)
- Exclude rough grazing

LFA was not considered to be an appropriate criterion. The designation is largely based on policy-related issues and lacks consistency across member States. In the UK, rough grazing is defined as

[6] http://www.defra.gov.uk/FARM/environment/land-manage/nutrient/fert/bsfp.htm

unimproved grazing that is not pasture, meadow or lowland grass. This provides a very useful and relevant way of defining the scope of the balance sheets.

We investigated the feasibility of identifying livestock grazed on rough grazing land. There are key data limitations that prevent this being done. Data is collected in the June Survey of Agriculture to estimate the number of livestock and cropping and land use. However, there is no direct link made between areas of land and where the livestock are grazed. It is therefore not possible to identify the number and type of livestock reared on the rough grazing land. Even if such data were available from the June Survey, this would only relate to the position on the snapshot date in June. Livestock movements during the year, which are known to take place on a significant scale, would not be recorded or reflected in the estimates.

These data limitations have an impact on the balance sheet estimates. Overall, the nutrient balances will slightly overestimate the total nutrient loadings. At a national level this will not be significant. At regional level, only those regions with significant areas of rough grazing will have balances that are overestimated. The overestimate will generally only apply to the manure from sheep component of the balance sheet.

To quantify the scale of errors for England balances:-

- Rough grazing accounts for about 12% of total grassland
- Manure from sheep accounts for 13% of total N from manure from livestock
- Manure from sheep accounts for 5% of total N inputs

Another scope issue is how to deal with uncropped land, either left fallow or set-aside. Given that neither land use will be fertilised, including the land area would give a misleading estimate of the balance per hectare as, in effect, the nutrient loading would be spread over a larger total area. Fallow and set-aside land should there be excluded from the balance sheets. A given parcel of land may move in and out of scope of the balance sheets from year to year but this is not a problem. This approach is consistent with the real world outcomes linked with nutrient surpluses, given that putting more land into fallow would not reduce the nutrient loadings on the fertilised land and would not reduce the risk of environmental damage.

3.2.2. Coefficients

Coefficients are used throughout the system to convert physical parameters such as number of livestock into nutrient levels. The main coefficients are applied to derive estimates of the following components of the balance sheets:-

- Level of N input from livestock
- Level of N input from mineral fertilisers
- Atmospheric deposition of N
- N input from seeds
- N fixation from legumes etc.
- N offtake from crop production

The input and offtake coefficients have a number of unusual properties that make them quite different from most sources of official statistics. This project considered a number of these properties and its implications for managing the data.

Data quality

The coefficients are derived from empirical research and their provenance can be hard to determine and document. It is difficult to assess the quality of the coefficients or to estimate ranges and error margins.

Coefficients used in the calculation of the balances reported here are derived from various sources including OECD/Eurostat default values current at 2008, results of recent scientific research (much of it commissioned by Defra and published in reports accessible from http://randd.defra.gov.uk/, and the scientific literature. The provenance of the coefficients used in this project has been documented and the values and metadata will be made available to Eurostat to be included in the proposed EU library.

Revisions

It is important to make a clear distinction between where a coefficient is revised to provide a better estimate and where it is updated to reflect a genuine change. Where a better estimate becomes available, the improved estimate will need to be applied retrospectively to historic data to produce a consistent time series.

Matching coefficients with physical data

It is essential to derive the coefficients to be consistent with the available physical data to which they will be applied. The coefficients for manure from livestock must be matched so as to be consistent with livestock categories from Farm Structure Survey data. The coefficients are derived to take into account systematic variation between different categories (e.g. age, size, weight) within a species. As a result there is not always a direct match between the coefficient categories and the categories for the livestock numbers. An approximation is made in the matching which introduces errors into the calculations.

Livestock data is based on a snapshot estimate for a specific point in time. Exact livestock numbers over a course of a year will vary as a result of production cycles and empty sheds. The coefficients have been derived to take this into account. If livestock data is collected on a different basis (e.g. population profile over the whole year) the coefficients would need to be adjusted to account for this.

Coefficients must also be matched correctly with the physical data in terms of moisture content. Crop production estimates will be based on a specific moisture content and this must be taken into account to ensure the coefficient is applied on an equivalent basis.

Variability in the coefficients

The coefficients represent average values, around which there is known to be significant variation. This variation will be both geographic and over time and is driven by a range of factors. Some of the variation is systematic (e.g. pasture quality) and others more random (e.g. feed regimes). If any of these variations are built into the coefficient values, it is important to be transparent about which factors are included. In practice, it is likely to prove difficult to take the random factors into account. The more systematic factors could be taken into account by the use of regional level coefficients but this would entail substantial additional experimental studies and data collection.

Where there may be variation over time, it may be difficult to make clear whether the change in the value of the coefficient over time reflects a genuine change (e.g. driven by improved farming practices) or whether it is a better estimate from new information. One approach to improve the transparency would be to use the same coefficient each year but apply an adjustment to take into account variation as a result of a correlated factor. The nutrient input from a dairy cow will vary with the milk yield. Rather than change the manure input coefficient every year to account for variation in milk yield, it would be more transparent to apply an adjustment factor to the coefficient. Other adjustment factors could also be applied in a similar way. The final coefficient would be different from the original coefficient but it would be apparent what adjustments had been made to it.

Harmonisation

Bearing in mind the issues outlined above, the proposal by Eurostat to develop and maintain a library for the coefficients for all Member States has considerable merit. To allow accurate and meaningful comparisons across different countries, it is essential to ensure a consistent approach to how the coefficients are developed and used.

Annex 1 - Flowchart of OECD spreadsheet system