CANTOGETHER

Crops and ANimals TOGETHER

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Towards land management of tomorrow - Innovative forms of mixed farming for optimised use of energy and nutrients

Deliverable D3.1: Protocol for data collection to study mixed farming systems at the district level

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Concerned workpackage leader: H. Korevaar

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Contents

1. Introduction

CANTOGETHER will conceive, evaluate and promote new mixed-crop livestock systems at farm, district and landscape levels to optimise energy, carbon and nutrient flows that conserve natural resources and maximise production. To this end, CANTOGETHER will develop and implement a methodological approach combining models, assessment methods and experimental approaches. CANTOGETHER will bring together data from a network of 25 case studies (Figure 1) based on existing field research platforms across a wide variety of agricultural regions of Europe and different systems (high input, organic, low external input, integrated, etc.) in which some innovative mixed-farming practices and systems will be implemented and monitored at farm and/or district levels. (CANTOGETHER, 2011).

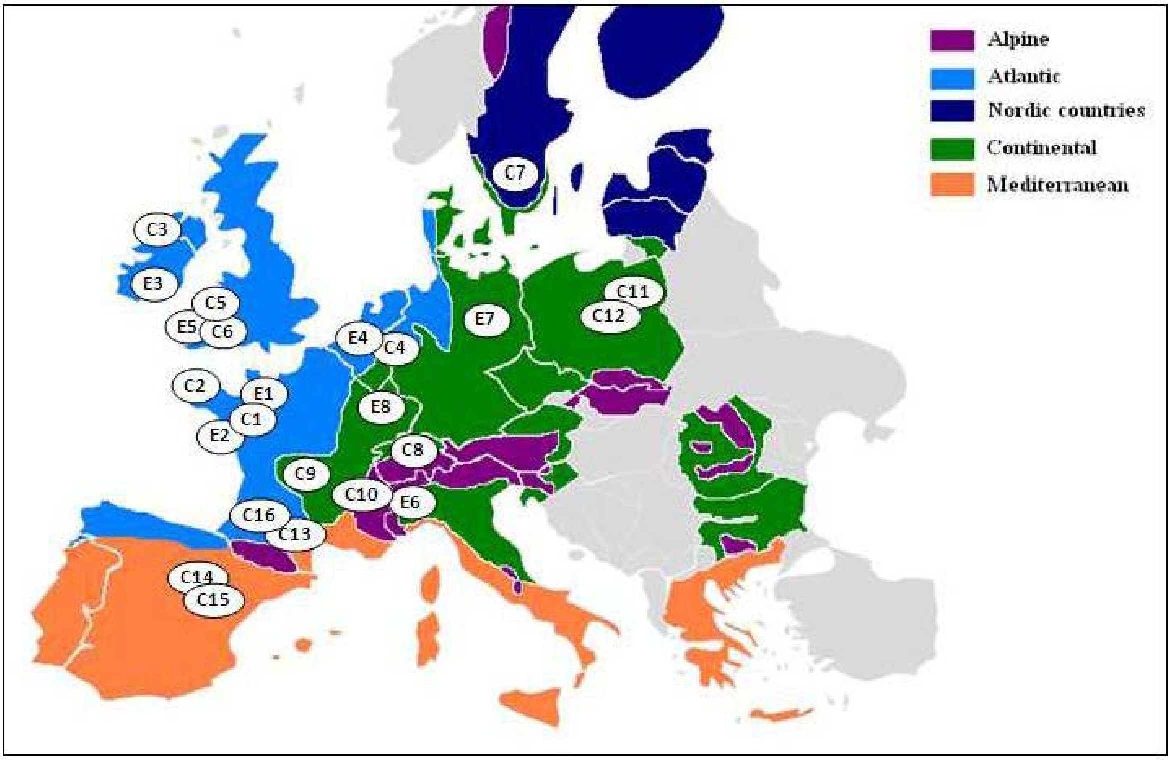

Figure 1. Locations of CANTOGETHER case studies in European biogeographic regions. Case studies with a C-number are commercial farms; case-studies with an E-number are experimental farms.

Drawing on these data, CANTOGETHER will design and implement new mixed farming systems, measure the environmental and socio-economic consequences of the most promising innovations, and test them with socioeconomic and biophysical models, following a multi-scale approach from the field to the landscape level. In CANTOGETHER the general components to be mixed are crop and animal production and optionally including energy production from agricultural processes in one enterprise or in a group of farms or even in regions (Grandl & Baumgartner, 2012).

In different tasks of CANTOGETHER WP2 (Workpackage 2) mixing at farm level is studied, that means within one enterprise between arable, dairy, piggery etc. activities. However there are more options to mix, for instance cooperation between different farms, between farmland, nature areas and areas with energy crops, and between farms and regional agribusiness.

Deliverable 3.1 focuses on case studies at the district level. Considering that there are large differences in soil and climate conditions, farm structure, cropping systems and farm management throughout Europe, we notice the need to develop a methodology to study mixed farming systems in different case studies and compare them with a baseline situation in that district. The baseline situation will be different for each case study. Often it will be the current agricultural practice. In some case studies, it will be specialised dairy farming, while in other regions it will be livestock farms growing cash crops and importing concentrates for their stock or farms transporting excess slurry over long distances to arable regions. Next to the regional differences, we also expect large differences in availability of data among the case studies, because we use data from case studies based on existing field research platforms (each platform having its own goals, methodology and level of precision of data collection). The definition of a district is not strict; it refers to a regional scale with spatial and organisational aspects. A district has administrative boundaries, and the scale of case studies at district level varies between the case studies. In some case studies the boundaries are not administrative, but set by the borders of a catchment or a landscape type.[1]

The objective for CANTOGETHER Task 3.1 is to develop a common methodology (= harmonised set of technical specifications for all regional case studies) for data collection and analysis of existing and future mixed farming systems at the district level. The data will be used in WP3 and other WPs of CANTOGETHER to analyse and evaluate:

- Performance of innovative mixed farming systems at district level in comparison to specialised farming systems.
- Optimisation of mixed farming systems at district level, in terms of decreasing production costs, improving resilience, adapting to risk, achieving sustainability, improving ecosystem services and facilitating nutrient cycle closure.
- Changes in land use and land cover by mixed farming systems in agricultural landscapes.

These data will be further used by WP4 and WP5 to perform overall assessments of existing mixed farming systems or the innovative mixed farming systems that will be implemented in case studies during the CANTOGETHER project.

[1] Caron (2005) identified different ways of analysing and acting upon territories. Based on examples from tropical agricultural research, he outlined four approaches to the territory: (i) regional ecosystem agronomy, (ii) agronomy focusing on technical issues at the territory level, (iii) territorial agronomy, (iv) integrative agronomy. He argued that what is defined as territory is not self-evident, but is not often debated. Recognition of the diversity of paradigms and methods by agronomists is a necessary step towards dealing with issues linked to the management of territorial resources.

2. Development of a methodology to study and compare mixed farming systems at the district level

2.1 Mixed farming compared to specialised farming

To assess the impact of a transition from specialised to innovative mixed farming on land use of the region, we compare the sustainability (based on agronomic, economic and environmental indicators) of mixed farming systems[2] in that region with the sustainability of farms specialised in livestock or in crop production. Mixing of livestock and crops is possible within a farm (within-farm mixing) or by cooperation of two (or more) specialised farms (among-farm mixing) (Figure 2). At regional level, a mixed farming system comprises at least two specialised farms, each producing crop or animal products in which decisions are made, taking into account goals and constraints of both farms. In mixed farming systems at regional level, the economic benefits of specialisation at farm level and environmental benefits of integrating cropping and livestock systems at regional level are combined (Bos and Van de Ven, 1999). Because of the large soil, climate and socio-economic differences between European regions, we focus first on differences between mixed and specialised farms within a region (or specific case study). A second step could be to compare the impact of crop - livestock integration among regions (or a number of case studies): which landscape features evolve and how; are the benefits noticed the same in all case studies or very differing; which ecosystem services are enhanced etc.?

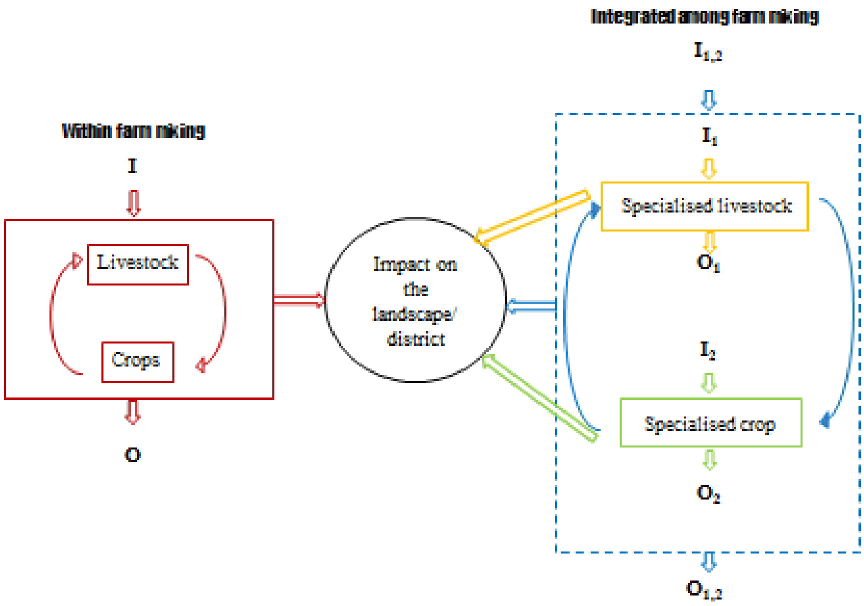

Figure 2. Mixing crop and livestock production within farms and among farms.

[2] The term 'mixed farming' can apply – and this is probably the most common use – to the combination of livestock and crop farming activities on the same farm. Yet, it is also feasible to term a group of farms or even regions to work in mixed farming systems or to name farms which grow grain and vegetable crops on their fields 'mixed farms' (Russelle et al., 2007 and Schiere and Kater, 2001 cited by Grandl and Baumgartner, 2012). In CANTOGETHER, the general components to be mixed are crop and animal production and optionally including energy production from on-farm grown biomass and livestock manure (CANTOGETHER, 2011).

2.2 Indicators for farming systems

To assess the performance of innovative mixed farming systems, we need agronomic, environmental, economic and social indicators at farm and district (or catchment or landscape) level. The literature includes a wealth of indicators and ways to make classification systems according to their subject, objectives, scales, data and specificity. Generally speaking, agronomic indicators in Europe rely on two scales associated with different types of data: a national scale at the FADN[3]-region level and a local scale at the district level (for instance, data collected already by previous projects in case study areas). From this assumption, the work of Bockstaller and Girardin (2003) defines two wider categories of indicators. The first type involves simple indicators resulting from measurements or estimations. Those will be more likely present in the local assessment. The second type is called composite indicators and is obtained by aggregation of simple indicators. Most FADN variables are aggregated or will be aggregated into composite indicators.

To study the sustainability of farming systems, we use three categories of indicators to suit the economic, environmental[4] and social goals of CANTOGETHER. Each of these categories of indicators may be defined more precisely depending on the type of assessment, the scale considered, the data available and the objectives to reach.

- Economic indicators: principally make use of FADN data to be applied at regional scale and throughout Europe. These indicators are used to compare farming systems with each other as well as to compare countries and case studies. However, the FADN classifies farms solely on their gross margin.
- Agri-environmental indicators: make use of locally collected data and apply to small areas. They are site specific and are used to assess and compare the impact of different farming systems on environmental quality and the landscape. These indicators will be important to consider to scale a farming system analysis up to a district analysis because they consider farms in their environments with their many interrelations between farms and soil, water quality, landscape etc.
- Social indicators: are scarce and in fact barely taken into account in most studies. In Europe, social parameters are probably more relevant to study at a larger scale than in a comparison of specialised and mixed farming systems. In CANTOGETHER social indicators will be focused on labour, other activities on the farm (such as agro-tourism), work outside the farm and cooperation between farms.

For the tasks in WP3, data are required on spatial parameters such as location and type of farms, hydrological conditions, soil type, soil organic matter, road networks, cooperation and transport between farms for exchange of feed and manure, land sharing, young stock rearing, renewable energy production, and on-farm production and management.

2.3 Development of a methodology

[3] **FADN**: Farm Accountancy Data Network. The FADN was designed in 1965 to assess economic impacts of European policies at the farm level. It now surveys the entire range of agricultural activities carried out on farms throughout the 27-country European Union. The European Union is divided into FADN regions whose sizes vary according to the country and its heterogeneity. FADN displays information about commercials farms, defined as “farms that are large enough to provide a main activity for the farmer and a level of income sufficient to support his or her family” (FADN, 2012).

[4] For more clarity, environmental indicators referring to agricultural assessments are named **agri-environmental indicators**.

Donzallaz (2012) reviewed the literature for more extensively and described objectives, criteria and indicators for agronomic, economic, environmental and social components of farming systems. He developed a methodology and proposed a harmonised set of indicators and tested this methodology in two of CANTOGETHER's case study regions. He concluded that it is possible to have a harmonised set of indicators at the FADN level to carry out an economic analysis at national level, but that it is not possible at the regional scale because:

- Data are presented at the scale of FADN regions, which are much bigger than the scale of the CANTOGETHER case studies.
- Case studies have heterogeneous data and diverging objectives.
- FADN data cannot capture the integration and innovative designs that CANTOGETHER seeks.
- The method has a theoretical approach, while CANTOGETHER needs a more robust and flexible approach to make good use of existing information and to cope with prospective data articulation with WP4 and WP5.

In CANTOGETHER's WP3 workshop (June 2012, Wageningen) and the meeting of the Executive Committee (July 2012, Paris) a first draft of Deliverable 3.1, with propositions of data and indicators for assessments of tasks 3.2 and 3.3 and for WP4 and WP5, was discussed extensively. We conclude that for the work to be done by WP3 and WP4, the FADN data are not very relevant since FADN regions are much bigger than the project's case study areas. It seems better for the project to collect its own data based on the requirements of WP3, WP4 and WP5, but not to build a new data-collection system, instead looking for an existing methodology. The DIALECTE tool, developed by Solagro[5] (Solagro, 2011; www.solagro.org), was mentioned as a relevant tool to assess the agro-environmental performances of farms (Pointereau *at al.*, 2012) participating in case studies at the district level.

Further investigation of the DIALECTE tool[6] confirms that DIALECTE could be a suitable tool for sustainability assessments at farm level. DIALECTE is less detailed than the data protocol of CANTOGETHER Task 2.1, but for farms in case studies at the district level the level of detail seems appropriate. However, a weak and unresolved point would be the up-scaling of DIALECTE data from farm to district level.

A methodology using the DIALECTE tool was developed, written in a second draft report for Deliverable 3.1 and discussed extensively at the first Annual Progress Meeting of CANTOGETHER (December 2012, Toulouse). The conclusion was that it would be inefficient and confusing to use different datasheets in WP2 and WP3. Because use of the DIALECTE tool was not accepted by the Consortium partners, it was decided to revise the methodology for data collection in WP3 again. Data collection will be based on the WP2 datasheet, and indicators too detailed for WP3 may be skipped. For spatial data at the district level and cooperation between farms, extra indicators and descriptions of how to collect them will be added to the protocol.

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[5] **Solagro** is a non-profit organisation, based in Toulouse, France. It was created in 1981. With a permanent team of 17 experts – agronomists, engineers in environmental sciences and energy, and economists – **Solagro**'s goal is to increase the range of technical options available to stakeholders involved in the fields of energy, agriculture and the environment (www.solagro.org).

[6] DIALECTE is a comprehensive, holistic and quick tool to assess the agro-environmental performance and ecological sustainability of farms that is applicable to any type of farming systems in Europe (Pointereau *et al.*, 2012). Solagro developed DIALECTE in 1995 with the support of public entities and adapts and improves it on a continuous basis. Currently, more than 3,000 farms have been evaluated in France, and 200 farms are being assessed in other European countries and about 300 farms are added per year. The objective was to build an easy-to-implement and affordable tool adapted to all types of farming systems to assess the impacts of farming practices on the environment at the farm scale. Since its creation in 1995, DIALECTE has made considerable improvements and extensions and has been translated into several languages. Widely tested in different studies (e.g., 200 farms from 11 countries were successfully assessed in the EU FP7 BioBio project), the DIALECTE tool has shown its utility.

3. Methodology

3.1 General remarks

In Section 2 we concluded that the WP3 methodology should adapt the protocol developed in WP2 for the farm level and add collection of data specific to the district level, such as spatial data and data about cooperation between farms.

3.2 Adaptations of the WP2 protocol

Deliverable D2.1 (Verloop *et al.*, 2012) contains a protocol to measure and collect data at the farm level in a harmonised way.

To obtain the same data calculations at the district level, the entire WP2 data-collection file DWP2E.xlsx has been copied to **datafile DWP3.xlsx**. In the **worksheet 'Data'** several lines have been highlighted in purple and with "NR" (not relevant) to indicate that these data can be considered more detailed than necessary at the district level. Of course, if desired, these lines can be filled with data. For experimental farms, data collection from several years is encouraged. At commercial farm level (farms participating in case studies at district level), data collection with a complete set of data is requested only for one year, preferably the most recent year. If data are missing most probably values may be filled in.

At the end of **the worksheet 'Data**' several extra lines (guidelines 705-743) have been added to collect data about ground water level, soil quality, slope, location of the farm and farm cooperation methods.

3.3 Number of farms to be examined in case studies at the district level

For CANTOGETHER case studies at the district level, the aim of data collection is to get a good understanding of the way farms are cooperating within the district. The number of farms needed to get that picture will depend on the goals set by the number of baselines in the case studies (Moraine et al., 2013A; 2013B) and the requirements of the specific tasks using these data (Regan, draft 26-7-2013). For a baseline we advise to collect data of 5-7 farms, depending on the heterogeneity in the district. For an innovative mixed farming system at the district level we advise a sample size of 7-10 farms.[7]

If the focus is to get average data for the case study, then we recommend a representative sample of 5-7 farms of the farm type of interest to assess current production (this could be the same group as one of the baselines). The results can be averaged into a 'representative farm' and compared to data in the FADN or local database.

We have to consider that at the district level it is more important to study the spatial and temporal interactions between collaborating farms in a district than to study the farms themselves (that is the task of WP2). For data collection, we prefer to collect data from the most recent year for which all data are available, but more important than the most recent year is to have data from the same year for all farms and the district.

[7] These numbers are a compromise between accuracy of data collection and available time/ costs, which makes it not possible to collect data on large numbers of farms.

The number of farms for each case study to fill in the data-collection worksheets will be worked out in more detail between each case study leader and the task leaders of WP3 and WP4 involved.

3.4 District-level data

We identified data specific to the district level that needs to be collected for subtasks 3.3.1 to 3.3.4 and WP4. They are described in the **worksheet 'Regional level data**' with guideline numbers 1001-1046.

3.5 Economic data

The datafile DWP3.xlsx has been extended with **four worksheets** defined by WP5 (Simon Moakes) for collecting data (**WP5 General; WP5 Land; WP5 Livestock; WP5 Income; WP5 Costs)** for economic analyses. There is some overlap with data in the 'Data' worksheet. When exactly the same data are requested, these cells are filled directly from the 'Data' or 'Fgate' worksheets; however, most of the requested data is different.

4. Explanation on required input data Worksheet 'Data'

4.1 General remarks

This chapter explains the data to supply in the datafile **'DWP3.xlsx', worksheet 'Data'.** Explanations that differ from those given in D2.1 by Verloop *et al.* (2012) are in **bold**.

- The explanations below refer to the numbers in column 'E'.
- When an explanation is valid for several input data, the explanation is only given once.
- Farms in district-level case studies should fill in the data marked in green. **Data marked in purple are not relevant at the district level.**
- Parameters marked in yellow are calculated. If you want, you can overwrite the formula. But note that it will be lost unless you repair it.
- To prevent errors in calculations, data must be entered in the correct units. Appendix 1 shows a list of units and conversion factors.
- For certain sites, some data will **not** be relevant. If so, replace 'FILL' by the number zero: '0'. If a value is not available, please replace 'FILL' by 'NA'.
- Data that are not relevant are indicated as 'NR'. This is done for your convenience, with if-then-else statements in the datasheet. This routine works when you fill in the data beginning at the top of the sheet.
- A completed sheet should not have cells indicating 'FILL'. At the end, all cells should contain a number, 'NR', '0' or 'NA'.

4.2 Explanation and remarks

Guideline nr.	Explanation/remark	Read more in
1	**Fill in**: the code that has been used in the Document of Work of CANTOGETHER Part B, Table 1, page 16, column 1.	
2	**Fill in**: the code that has been used in the Document of Work of CANTOGETHER Part B, Table 1, page 16, column 2.	
3	Choose from the pick list	
4	Fill in: the calendar year for the reference situation and for research years, or: 1. If the reference situation is an average of farm results recorded in several years, fill in the first calendar year. 2. If the reference situation is an estimate based on results from other farms, models or other data, fill in: 0.	
5	1. For research years, fill in: 1, 2. For reference situation: a. fill in 1 if the reference situation is based on one year, b. fill in the number of years involved (>1) if the reference situation is based on more years.	
6	Fill in: With Google Maps, the site can be found and a satellite view can be printed. Remark: longitude is asked in guideline 720	
7	Above sea level	
8	Choose from the pick list: the predominant texture of the site. Differences between parcels can be neglected.	
9	Clay content: kg per kg soil (mass %) This is the average content of the soil (layer 0 to 90 cm depth or less if soil is shallow). The farm average is established for the surface dedicated to the farm (see also guideline 18). If the % of clay is 25 in 80% of the farmland and 40 in the other 20% of	

	the farmland, the average clay % of the farmland is: 0.8*25%+0.2*40%. Remark: In some countries, like the Netherlands, standard soil sampling depth is 0-10 cm for grassland and 0-25 cm for arable land. Sampling depth is asked to fill in lines 70 and 72.	
10	Sand content: % based on mass. Further remarks, see 9.	
11	Silt content: % based on mass. Further remarks, see 9.	
12	Organic matter content: % based on mass for whole farm. Further remarks, see 9. Remark: To study the impact of mixing arable, livestock and nature, in guidelines 707-709 is asked to fill in the organic matter content for grassland, arable fields and nature areas. The C content of the soil is asked in guideline 710.	
13	For reference (0-situation) fill in: the average rainfall for the last 10, 20 or 30 years. This figure will be the same for all farms in a case study, unless the district is very large.	
14	Winter rain = the rain from 1st of October to 1st of March for all sites. Further remarks: see 13.	
15	Fill in: number of days per year with precipitation < evapotranspiration. Further remarks: see 13.	
16	This is the annual rainfall minus the evapotranspiration. If, in some periods of the year the water balance is negative, this does not change the calculation method (don't use the default value 0 for negative water balances). Further remarks: see 13.	
18	Fill in: the area that belongs to the farm (including land that is rented) and used for agri-production (i.e.: crop and/or animal production, energy production (except wood).	
19	This is the area that belongs to the farm, but that is not used for production, for example: forests, lakes, natural area	
20	Fill in: the area that is also used by others (collective mountain pasture for sheep or beef). Fill in no if there is no collective use.	
21	Fill in: the area used as permanent grassland, i.e.: sward is only destructed for reseeding and the aim is to realize a sward age higher than 5 years	
22	Fill in: the average age of sward in permanent grassland, i.e.: the years since the last incidence of reseeding (average age weighed over hectares)	
23	Fill in: the soil organic matter content (%) in grassland at the time of reseeding. Sampling depth, see 9.	
24	Fill in: the grassland area minus the area of permanent grassland Remark: permanent grassland is grassland older ≥ 5years.	
25	Fill in: the average age of sward in temporary grassland in the year that it is ploughed to turn it into arable land (average age weighed over hectares)	
26	Fill in: the area used for grass-legume mixtures, i.e. legume contributes in at least 2,5% of dry matter yield of the grass-legume mixture. For explanation on the way to determine this, see Appendix 1	Appendix 1
27	Fill in: the average % of clover (% of dry matter yield) in grass-clover mixtures (average weighed over area). For explanation on the way to determine this, see Appendix 1	Appendix 1
28	Fill in: the area of maize that is grown continuously (more than 6 years) on the same land (not in rotation with other crops).	
29	Fill in: the area of maize that is grown in rotation with grassland	
30	Fill in: the area of maize that is grown in rotation with other crops	
31	Fill in: the area of land dedicated to grow maize used for making CCM (silage of corn and kernels).	
32	Fill in: the area of land dedicated to grow alfalfa	
33	Fill in: the area of land dedicated to grow the specified crop (same for other crops)	

44	Fill in: the area of land dedicated to grow crops not specified earlier and specify the crop in column C (same for 45)	
46	Fill in for the specified crops: the area of land dedicated to grow crops that are sold and exported (as arable crops or as roughage for other farmers). Remark: In guidelines 732-734 the proportion of products sold in own region (case study area) is asked.	
59	Fill in for crops not specified before: the area of land dedicated to grow crops that are sold and exported (as arable crops or as roughage for other farmers) and specify the crop in column C (same for 60)	
61	Fill in for the specified crops: the area of land dedicated to grow crops used for energy production by fermentation. Remark: no doubling with area of maize grown for silage or CCM, guidelines 28-31.	
62	Fill in for crops not specified before: the area of land dedicated to grow crops used for energy production by fermentation and specify the crops in column C (same for 63)	
64	Fill in: the area of land used for crop rotations without a grassland phase	
65	Fill in: the length in years of a complete rotation	
66	Fill in: the area of land used for crop rotations with a grassland phase	
67	Fill in: the number of years of grassland in a complete (grass-arable) rotation cycle	
68	Fill in: the number of years of arable crops in a complete (grass-arable) rotation cycle	
69	Fill in: the soil organic matter content under grassland at the time of ploughing to turn it into arable land. Use one sample, taken at the right moment or fill in the average of replicate samples.	
70	Fill in: the sampling depth (cm below soil surface). Further remarks, see 9.	
71	Fill in: the soil organic matter content under arable land at the time of turning it into temporary grassland. Use one sample, taken at the right moment or fill in the average of replicate samples.	
72	Fill in: the sampling depth (cm below soil surface). Further remarks, see 9.	
73	Fill in: the area of grassland with restrictions in use or management coming from agro-environmental agreements/contracts	
74	Same as 70 but now for arable land	
75	For the section on Farm gate balance (lines 75 - 106), the 'Fgate' worksheets should be filled in. Data from these worksheets are imported in worksheet 'Mineral balance' and from there in worksheet 'Data'. For further information see Apendix1. Start with worksheet 'Fgate Animals'	Appendix 1
76	Go to worksheet 'Fgate MinFert.'	Appendix 1
77	Go to worksheet 'Fgate OrgFert'	Appendix 1
78	Go to worksheet 'Fgate Plant'	Appendix 1
79	Go to worksheet 'Fgate Conc'	Appendix 1
80	Go to worksheet 'Fgate Other'	Appendix 1
81	Go to worksheet 'Fgate Other'	Appendix 1
82	Fill in: N inputs that do not belong to the categories mentioned above	Appendix 1
83	Go to worksheet 'Fgate Output'	Appendix 1
84	Go to worksheet 'Fgate Animals'	Appendix 1
85	N outputs that do not belong to the categories mentioned above (imported from 'Fgate Output')	Appendix 1
86	Go to worksheet 'Fgate OrgFert'	Appendix 1
87	Go to worksheet 'Fgate Animals'	Appendix 1

88	Go to worksheet 'Fgate MinFert.'	Appendix 1
89	Go to worksheet 'Fgate OrgFert'	Appendix 1
90	Go to worksheet 'Fgate Plant'	Appendix 1
91	Go to worksheet 'Fgate Conc'	Appendix 1
92	See explanations for N input	Appendix 1
107	Fill in: the milk production (dairy) that is attributed to the farm by government	
108	Fill in: the actual annual milk production, including losses (penicillin), private use or direct selling from farm	
109	Choose from pick list, breeds not in the list could be specified in column H	
110	Imported from worksheet 'Fgate Animals'	
116	Imported from worksheet 'Fgate Animals'	
123	Fill in: number of animals belonging to the specified animal group	
137	Specify livestock (column C) and fill in the number of animals	
138	Imported from other worksheets. This can be established using the standard values of Appendix 8 (this Guideline) and the number of animals and the total agricultural area (same for 139).	
140	Choose from pick list: the housing facility where the specified animal group is housed. If you cannot see the complete description, extend the width of the cell by dragging the boarder. After choosing, you can restore the format of the column again.	
145	If housing facility is not in the pick list, specify the housing facility	
150	Fill in: the number of days after calving until the next calving	
152	Choose from pick list: 'spring calving' when most calves are born in spring 'evenly distributed' when calving occurs during the whole year or 'other'	
153	This value can be determined by sampling of the animal group. Check if sampling must be done each year	
154	This value can be determined by sampling the animal group. Check if sampling must be done each year.	
155	This is determined as: N feed intake (kg per year) - N fixed by the animals in milk and meat (kg per year). If it is difficult to calculate this, you might use standard values for N excretion per animal. If required, an overview of standard values will be supplied.	Appendix 3
156	This is determined as: P feed intake (kg per year) - P fixed by the animals in milk and meat (kg per year). See also 155 (above).	Appendix 3
157	Fill in: the increase in weight per day (average for the specified animal group)	
158	Fill in: the live weight of the animal sold and exported from the farm	
159	Fill in: the % of the live weight that results in carcass weight	
162	This is determined as: N feed intake (kg per year) – N fixed by the animals in meat (kg per year). See also 155 (above).	Appendix 3
163	This is determined as: P feed intake (kg P per year) – P fixed by the animals in meat (kg per year). See also 155 (above).	Appendix 3
171	Fill in: the % of animals that died on the farm	
172	This is determined as: N feed intake (kg per year) – N fixed by the animals in meat (kg per year). See also 155 (above).	Appendix 3
173	This is determined as: P feed intake (kg P per year) – P fixed by the animals in meat (kg per year). See also 155 (above).	Appendix 3
183	This is determined as: N feed intake (kg per year) – N fixed by the animals in meat and eggs (kg per year). See also 155 (above).	Appendix 3
184	This is determined as: P feed intake (kg P per year) – P fixed by the animals in meat and	Appendix 3

	eggs (kg per year). See also 155 (above).	
187	This is determined as: N feed intake (kg per year) – N fixed by the animals in meat, milk and wool (kg per year). See also 155 (above).	Appendix 3
188	This is determined as: P feed intake (kg P per year) – P fixed by the animals in meat, milk and wool (kg per year). See also 155 (above).	Appendix 3
190	This is determined as: N feed intake (kg per year) – N fixed by the animals in meat and milk (kg per year)	Appendix 3
191	This is determined as: P feed intake (kg P per year) – P fixed by the animals in meat and milk (kg per year).	Appendix 3
192	Concentrates are feeds of which the energy and proteins are concentrated by removing a large part of the water, resulting in feeds with a dry matter percentage of more than 80. Attention: concentrates are recorded in tonnes. The data in 192 to 203 should be consistent with the data in worksheet 'Fgate Plant'. We did not link them directly to offer sufficient flexibility in 'Fgate Plant' on the use of categories of feedstuff. Please specify name and/or composition of the cereals in column H.	
195	Specify the name and composition of compound feed in column H	
196	By products are wastes with nutritious value that are produced upon manufacturing other food, often with a low dry matter percentage. By products are recorded in tonnes DM, just like other feed categories	
199	Specify other by products in column H	
200	Fill in: the amount of silage maize imported to the farm	
201	Fill in: the amount of grass imported to the farm	
202	Fill in: the amount of alfalfa imported to the farm	
208	This is roughage offered minus refusal	Appendix 3
209	This is: The average content of all roughages used. Calculate this from the contents of components and the amount of the components used ((tonnes Maize silage*N content Maize silage+ tonnes Hay*N content Hay +...)/(tonnes Maize silage + Hay +...) (Same for 210 and 211 but replace N content by P content (210) or energy content(211)). An overview of the main standard values will be assembled for each region and will be supplied.	
216	Fill in: the amount of the specified feeds offered to milking cows and young stock that is raised to replace milking cows. This is determined by recording the ration. For details see Guidelines, section 5.	Appendix 3
227	Fill in: the amount of the specified concentrates to the milking cattle	Appendix 3
234	Fill in: the amount of other feeds offered to milking cattle. This is determined by recording the ration.	Appendix 3
235	Fill in: the area that was dedicated to grazing over the year. Remark: area used for all types of grazing: set stocking, rotational grazing and alternating grazing and mowing	
236	Fill in: the number of days that the group of animals was allowed to graze	
239	Fill in: the average number of grazing hours per day	
336	Fill in: the capacity of the facility	
340	Fill in: the capacity of the facility and specify in column C (replace 'other')	
341	Average time between arrival in the slurry pit and time it is spread on fields	
342	Fill in: the amount produced per year for the specified animal groups	
352	Fill in: the amount per year separated from slurry milking cattle	
358	Fill in: the amount per year separated from mixed slurry	

360	Data from nr 360 to 379 are imported from worksheet 'Fgate OrgFert'. We assume that the density of slurries is 1 tonne per m^3	
399	Specify the treatment	
400	Specify the kind of manure that is treated	
403	If manure is treated with a biological filter, N may be volatilized as N2 or N2O after denitrification. Estimate the amount. This might be done using N content inflow* mass inflow-N content effl* mass effluent	
404	Data from nr 404 to 413 are imported from worksheet 'Fgate OrgFert'. We assume that the density of slurries is 1 tonne per m^3	
414	This means: slurry is spread over a width of mostly about 5 meters from a tank	
415	This means: slurry is placed in narrow bands on the soil surface between grass leaves	
416	This means: knives or disc coulters are used to cut vertical slots in the soil into which slurry is placed	
418	This means: the manure is covered by soil by ploughing after manure supply	
419	This means: slurry is injected in the soil	
422	Fill in: rate of supply and specify in column C	
424	Fill in: the sum of ammoniacal N supplied with slurries	
425	Fill in: the sum of P supplied by slurries (P = phosphate/2.29)	
440	This is the sum of pasture intake by grazing animals divided by the grassland area. Note: do not divide by only the pasture area	Appendix 3
441	This is determined by measuring the N content in fresh grass	Appendix 3
442	This is determined by measuring the P content in fresh grass	Appendix 3
463	Choose from the pick list	
464	Choose from the pick list	
618	Fill the data on energy consumption using first part of worksheet 'Energy use'	Appendix 2
694	Fill in: the amount of energy supplied in the form of upgraded biogas that could be used as a fuel	
695	Fill in: the amount of energy supplied as electricity produced by a power station	
696	Fill in: the amount energy produced as usable heat. Often, this is very difficult to establish. If not available, fill 'NA'.	
697	Fill in: the amount of energy produced as usable electricity	
698	Fill in: the amount energy produced as usable heat	
699	Fill in: the amount of energy supplied as electricity	
700	Water use on the farm other than irrigation. Fill in Irrigation water use in 704	
702	Water use for crop production	
705	Fill in: average winter ground water level (November-March) in cm below ground level	
706	Fill in: average summer ground water level (May-September) in cm below ground level	
707	Organic matter content of permanent grassland: % based on mass, see 9	
708	Organic matter content of arable fields and temporary grassland: % based on mass, see 9	
709	Organic matter content of nature conservation areas: % based on mass, see 9	
710	Average C content of the soil, see 9 and 12	
711	Average N content of the soil, see 9	
712	Average P content of the soil, see 9	
713	Fill in: method to analyse P content	
714	Average pH of the soil, see 9	

715	Fill in: method to analyse pH (e.g. pH-KCl, pH-H_2O)
716	Fill in: percentage of UAA with slope < 18%
717	Fill in: percentage of UAA with slope 18-35%
718	Fill in: percentage of UAA with slope > 35%
719	Data are imported (see guideline 6)
720	Fill in (see guideline 6)
721	Fill in: the shortest linear distance between farm buildings and the nearest nature reserve
722	Fill in: number of fte (full time equivalent) labour the farmer, his family and co-workers spend on agricultural activities on own farm
723	Number of fte (full time equivalent) labour the farmer, his family and co-workers spend on non-agricultural activities on own farm
724	Number of fte (full time equivalent) labour the farmer himself has a paid job outside the farm
725	Total number of nights guest stayed at the farm during one year
726	Fill in: type of exchange (manure, forages, crops) directly from farm to 'linked' other farm(s)
727	Quantity of products exchanged with other farms
728	Distance between farms mentioned in guideline 726
729	Method of transport (e.g. train, truck, tractor)
730	Number of machines shared with other farms
731	Number of farms participating in sharing
732	Percentage of products sold in own region (= case study area)
733	Percentage of products sold outside own region (= case study area)
734	Percentage of products sold with destination unknown
735	Area harvest for dehydration of forages
736	Total mass harvested for dehydration per year
741	Specify crop harvested for dehydration other than grass, grass-clover and alfalfa

5. Explanation on required input data Worksheet ‘Regional level data’

5.1 General remarks

This chapter explains the data to supply in datafile **‘DWP3.xlsx’, worksheet ‘Regional level data’**, which refers to the district/catchment level. These guidelines are not included in D2.1 (Verloop *et al.*, 2012).

- The explanations below refer to the numbers in column ‘E’.
- When an explanation is valid for several input data, the explanation is only given once.
- The ‘Regional-level data’ worksheet should be filled in only once for a case study since district-level data are equal for all farms in a case study.
- To prevent errors in calculations, data must be entered in the correct units.
- For certain sites, some data will **not** be relevant. If so, replace ‘FILL’ by the number zero: ‘0’. If a value is not available, please replace ‘FILL’ by ‘NA’.
- Data that are not relevant are indicated as ‘NR’. This is done for your convenience, with if-then-else statements in the datasheet. This routine works when you fill in the data beginning at the top of the sheet.
- A completed sheet should not have cells indicating ‘FILL’. At the end, all cells should contain a number, ‘NR’, ‘0’ or ‘NA’.

5.2 Explanation and remarks

Guideline nr.	Explanation/remark	**Read more in guideline**
1001	Code will be imported from Worksheet ‘Data’ (see guideline 1)	1
1002	Code will be imported from Worksheet ‘Data’ (see guideline 2)	2
1003	Year will be imported from Worksheet ‘Data’ (see guideline 4)	4
1004	Fill in: total area of case study area including non-agricultural area, excluding built-up area by towns, industrial areas	
1005	Fill in: total number of farms counted in the regional surveys	
1006	Fill in: number of farms selected in this case study to collect data; for explanation see Section 3.3	
1007	Mean road distance between the farms from which data are collected	
1008	Road density in the district, expressed as the length of roads (m) per ha in the district excluding built-up areas	
1009	Density of the hydrographic network in the district, expressed as the length of waterways (m) wider than 3 m per ha in the district excluding built-up areas	
1010	Fill in: total natural area in the case study	
1011	Percentage of surface water samples exceeding the water framework directive guideline for total N concentration in the surface water of the case study (for the Netherlands the target for summer months is 2.2 mg/l total-N)	
1012	Water frame directive guideline value for total N for summer months (EU) or a comparable target for Switzerland. Remark: The guideline values are not the same in all countries, therefore the national (or local) target value has be filled in.	
1013	Total number of surface water samples with analyses of total-N concentration.	

1014	Percentage of surface water samples exceeding the water framework directive guideline for total P concentration in the surface water of the case study (for the Netherlands the target for summer months is 0.15 mg/l total-P)	
1015	Water frame directive guideline value for total P for summer months (EU) or a comparable target for Switzerland. Remark: The guideline values are not the same in all countries, therefore the national (or local) target value has be filled in.	
1014	Total number of surface water samples with analyses of total-P concentration	
1017	Percentage of CS area covered by farm type 'arable'	3
1018	1018-1024 Percentage of CS area covered by other farm types and non-agricultural land	
1025	Percentage of CS area covered by main crop grassland	
1026	Percentage of CS area covered by main crop silage maize	
1027	1027-1031 Percentage of CS area covered by the 5 most important crops besides grassland and silage maize	
1032	Percentage of CS area covered by non-agricultural land-use features	
1037	Number of machines for maintaining non-agricultural land-use types by farmers	
1038	Number of farms in CS sharing machines for maintenance of non-agricultural land-use types	
1039	Transport costs for manure	
1041	Transport cost for forages from field to dehydration unit and from dehydration unit to farm	
1042	Mean distances between representative farms and main factories such as grain mills to sell grain or buy concentrates	

6. Explanation on required input data Worksheet 'WP5 Economic Analysis'

6.1 General remarks

This chapter explains the data to supply in datafile **'DWP3.xlsx', worksheets 'WP5 General', 'WP5 Land', 'WP5 Livestock', 'WP5 Income' and WP5 Costs**, which refers to data collection for economic analyses by WP5. These worksheets are provided by Simon Moakes (Aberystwyth University), they are not included in D2.1 (Verloop *et al.*, 2012).

- The explanations below refer to the numbers in the **green** column.
- When an explanation is valid for several input data, the explanation is only given once.
- The Worksheets 'WP5.....' should be filled in for all selected farms. To prevent errors in calculations, data must be entered in the correct units.
- For certain farms, some data will **not** be relevant. If so, fill in the number zero: '0'. If a value is not available, please fill in 'NA'.
- Data that are not relevant are indicated as 'NR' at the district level.
- A completed sheet should not have cells indicating 'FILL'. At the end, all cells should contain a number, 'NR', '0' or 'NA'.

6.2 Explanation and remarks

Guideline nr.	Explanation/remark	**Read more in guideline**
	Worksheet WP5 General: General characteristics of the farm	
2001	Code will be imported from Worksheet 'Data' (see guideline 1)	1
2002	Code number of the farm Remark: to respect confidentiality the contact person is the only one who know the name and address of the farm, others are working with farm code number. To get unique numbers, combine case study code with a following number, for instance: C1-1	
2003	Code will be imported from Worksheet 'Data' (see guideline 2)	2
2005	Name of CANTOGETHER contact person for case study	
2006	E-mail address of contact person	
2007	Fill in number '1' in boxes when appropriate. Animal numbers and ha are filled in in following worksheets	
2015	Code will be imported from Worksheet 'Data' (see guideline 7)	7
2016	LFA: less favoured area	
2019	Not relevant at district level, but could be relevant for case studies at farm level	
2024	Fill in data for most recent year available	
	Worksheet WP5 Land: Area in livestock and arable enterprises	
2025	Fill in: crop name Remark: to prevent double counting which might occur where you have two harvests in one year (e.g. cash crop and cover crop), fill in only the main crop	
2027	Forage crop 4 till 6: fill in their name(s)	
2029	2029-2033 fill in, in ha	
2034	Fill in same crop names as guideline 2025	
2035	Fill in: total amount for the crop on the farm (in t/farm; not in t/ha)	

2040	From the amount of own grain used on farm, X% is used for dairy
	Worksheet WP5 Livestock: Livestock data
2058	Number of dairy cows at the beginning and the end of the financial year and their average value at the beginning and the end of the financial year
2069	Average weight of the animals at the beginning and the end of the financial year
	Worksheet WP5 Income: General income In this worksheet, data are filled in for income received from milk, livestock sales and other sources such as subsidies. In the first table (guidelines 2087-2092), enter any additional general income and allocate to the correct enterprise wherever possible, such as shearing contractor (sheep). Wool payments and any other miscellaneous income such as TB compensation, insurance claims and quota leasing should be entered into the 'other income section'. For subsidies, please enter your Single Farm Payment, LFA, Agri-Environment and Organic Farming payments.
	Enter for the appropriate enterprise the physical sales off the farm in litres of milk or live or dead weight of the animal and the number of animals sold *plus* the monies received for their sale. For beef and sheep enterprises, the killing out percentages can be adjusted. 'Changes of numbers in each category' means the increase or decrease in trading stock through death, sale or purchase in one year, so the number of animals at year beginning minus the number of animals at the year end, accounting for transfers will equal to zero.
2089	Fill in total income per farm per year for activities and for different subsidies
	Worksheet WP5 Costs:
2149	Fill in costs for different categories.
2159	Fill in names of the different arable crops. Use same names as in line 2025
2164	Fill in names of the different forage crops. Use same names as in line 2027.

7. Final remarks

In Deliverable 2.1, ‘Harmonized protocol data to be measured and collected’ (Verloop *et al.*, 2012), more detailed information on methods to measure or estimate data is presented in Chapters 3-9. At the district level not all this information is relevant. The most relevant parts have been added to this report as Appendixes 1-4. The items addressed are:

Appendix 1:	Farm-gate N, P, C balances
Appendix 2:	Farm energy use and energy production
Appendix 3:	Use of pesticides
Appendix 4:	Units and conversion factors

References

Bockstaller C, Girardin P, 2003. How to validate environmental indicators. Agricultural Systems 76: 639-653.

Bos JFFP, Van de Ven GWJ, 1999. Mixing specialised farming systems in Flevoland (the Netherlands): agronomic, environmental and socio-economic effects. Netherlands Journal of Agricultural Science 47: 185-195.

CANTOGETHER, 2011.Towards land management of tomorrow – Innovative forms of mixed farming for optimized use of energy and nutrients. Description of work. Collaborative project EU-FP7-KBBE-2011-5, INRA, Rennes, France.

Caron P, 2005. À quels territoires s'intéressent les agronomes ? Le point de vue d'un géographe tropicaliste. Natures Sciences Sociétés 13: 145-153.

Donzallaz G, 2012. A methodology to compare specialized and mixed farming systems. Case studies in the Netherlands and France. Master thesis. ISARA Lyon, France/UMB Ås, Norway.

FADN, 2012. Concept of FADN. http://ec.europa.eu/agriculture/rica/concept_en.cfm . (Accessed 15/06/2012)

Grandl F, Baumgartner D, 2012. Synthetic report describing the case studies. Deliverable 1.1. FP7 CANTOGETHER Collaborative project EU-FP7-289328, INRA, Rennes, France.

Moraine M, Therond O, Duru M, 2013A. Deliverable D1.3: Design methodology in CANTOGETHER project.. CANTOGETHER. Collaborative project EU-FP7-289328, INRA, Rennes, France.

Moraine M, Therond O, Carof M, Duru M, 2013B. Deliverable D1.4-5: Innovative MFS and ex ante evaluation based on Light Design methodology. CANTOGETHER. Collaborative project EU-FP7-289328, INRA, Rennes, France.

Pointereau P, Langevin B, Gimaret M, 2012 DIALECTE, a comprehensive and quick tool to assess the agro-environmental performance of farms. IFSA Symposium 2012. Workshop 1.3 Understanding agricultural structural changes and their impacts. 1-4 July Arrhus, Denmark.

Russelle MP, Entz MH, Franzluebbers AJ, 2007. Reconsidering Integrated Crop–Livestock Systems in North America. Agronomy Journal 99: 325-334.

Solagro, 2011. Manuel DIALECTE. Rapport version 3 de janvier 2011. http://dialecte.solagro.org/

Verloop K, Vertès F, Humphries J, Burchill W, Loges R, Mantovi P, Oenema J, Chambaut H, 2012. Deliverable D2.1: Harmonized protocol data to be measured and collected. CANTOGETHER. Collaborative project EU-FP7-289328, INRA, Rennes, France.

Appendix I Farm gate balances for N, P and C

I.1 Main line

The farm-gate balance is defined as the sum of inputs minus the sum of outputs for a production system (Figure I.1). Inputs are the inputs by means of human activity (transport, purchase or trade is involved) or by natural processes (atmospheric deposition, N fixation). Outputs are outputs in the form of products. The difference between inputs and outputs are surpluses. For N and P high surpluses are in general associated to losses (leaching, runoff, volatilisation). Nevertheless, some of N and C surplus can be stored in soil (organic matter) and contribute to an increase of soil fertility.

The farm-gate balance is established for N, P, C.

To make a farm gate balance, all relevant inputs and all outputs must be recorded. For a lot of inputs this is done by multiplying an (organic) **mass flow** containing N, P and C with the **contents** of the nutrients.

Note that: when a mass flow is expressed in kg dry matter, the content must be expressed in kg per kg dry matter and when a mass flow is expressed in kg of total mass, the content must be expressed in kg per kg of total mass.

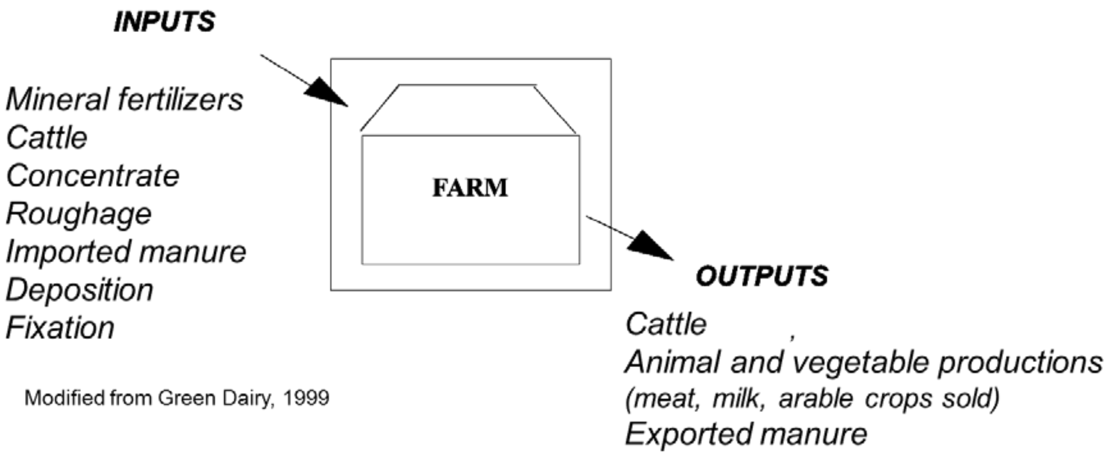

Figure I.1: Inputs and outputs for a farming production system.

The farm-gate balance does not give any information on how nutrients flow through production systems and how the different components interact; instead, it indicates the performance for N, P and C. It can be used to express and compare (developments of) systems:

1. Resource use efficiency
2. Environmental pressure (caused by surpluses)

I.2 Stocks

In the datafile: DWP2E.xlsx, 'Fgate sheets' are prepared to record specific in and outputs (animals, mineral fertilisers, organic fertiliser, plants material, concentrates and 'others'). In each of these sheets stock are taken into account.

Changes in amounts of stock may concern increase or decrease of silage or hay stored, increase or decrease of animals on the farm, etcetera. On some farms it is not necessary to record change in stocks (see below, agreements). In case changes are taken into account, this is done as follows:

1. If the amount of a specific input (for example mineral fertiliser or feedstuff) that is stored on the farm increases in a year x, the increase of storage stocked input is not taken up in the N, P, C flows of the farming system in year x:

   Input in year x = purchased input – increase in stock

   Example A: if a pig farm purchased 20 tonnes of corn in year x, of which 5 tonnes are kept in stock and are not used in year x, then only 15 tonnes are taken up in the farm feed cycle and only the amount of N,P, C corresponding to 15 tonnes are taken up in the farm N,P, C cycle. So, the input in year x is based on 15 tonnes, not 20 tonnes.

2. If the amount of a specific input (for example mineral fertiliser or feedstuff) that is stored on the farm decreases in a year x, the amount taken up from the stock is taken up in the N, P, C flows of the farming system and must be added to the inputs.

   Input in year x = purchased input + decrease in stock

   Example B: if the farm mentioned above purchases 5 tonnes of corn in year x, completely uses it for feeding and also uses for feeding 15 tonnes that was left over in stock from year x-1, then 20 tonnes (5 purchased and 15 by using stored material) are taken up in the farm feed cycle and the corresponding N, P, C should be taken into account.

3. If there is an increase in the amount of an output (an animal or plant product or manure, as defined above) that is stored on the farm in a year x, this material is added to the farm outputs of N, P, C flows of the farming system:

   Output in year x = output sold + increase in output stocked

   Example C: a dairy farm stores 50 tonnes grass silage in year x, while before, it stored only 25 tonnes. In year x it produced 25 tonnes grass silage that were not exported from the farm, but in fact exported to the next year. So this 'export', the increase in output stocked, should be taken into account in year x, just like the corresponding N, P, C. If this is not done, the calculated NUE (ratio of nutrient inputs/nutrient outputs) will be biased.

4. If there is a decrease in the amount of an output (an animal or plant product or manure, as defined above) that is stored on the farm in a year x, the amount taken up from the stock is subtracted from the N, P, C outputs of the farming system and must be subtracted from the outputs.

   Output in year x = output sold - decrease in output stocked

> Agreement on dealing with stock changes:
>
> 1. Evaluations of farm performances (surpluses, and efficiency) are based on farm-gate balances that are corrected for changes of stock.
> 2. This is not necessary on all farms. On commercial farms that do not export manure and that do not increase or decrease their production or herd over time (years), changes in stock can be neglected.

I.3 Symbiotic N fixation and atmospheric deposition

I.3.1 N fixation (worksheet Fgate other)

Legumes are able to fix N by symbiotic interaction of legume crops with root bacteria. The most common legumes are:

- Clover (white or red) in mixtures with grasses
- Alfalfa (pure stand or mixtures with grasses or cereals)
- Peas (pure stand or mixtures with cereals)

N fixation rate is commonly estimated by:

1. Determining the dry matter yield of the legume (= total DM * % legume)
2. Estimating N fixation rate using a standard value per ton dry matter of the legume (N content in legume * %Ndf) with Ndf = N derived from fixation.

Both steps are subject to an on-going debate. The main questions are:

1. How can the dry matter yield of the legume be estimated adequately? and
2. What standard value gives the best estimate of N fixation per ton dry matter (values vary from 31 to 60 kg N per ton dry matter).

Furthermore, in some studies a distinction is made between N that is accumulated in the above-ground parts of the plant and below-ground parts. In the case of white clover, whose stolons are on or below the ground and represent a high part of total production, a coefficient is usually applied to take this biomass into account, which varies among authors from 1.3 to 1.7.

> In CANTOGETHER:
>
> 1. N fixation refers to total N fixation, i.e. not the N fixed in only the aboveground plant material.
> 2. It is assumed that N fixation can be estimated for the variety of N-fixing species with the same standard value per ton dry matter;

3. It is assumed that fixation rate is not affected by soil N (e.g. fertiliser inputs)
4. The following standard is used for white clover (ref):

   N fixed (kg N.ha $^{-1}$*) = DM yield of legume (1000 kg ha*$^{-1}$*) × 35 fixed N (kg N per 1000 kg* $^{-1}$ *of DM yield of legume) × fixation rate × 1.3*

   Where:
   1.3 is the coefficient proposed to estimate the below-ground fixation contribution
   DM yield of legume refers to above-ground production
   fixation rate is the proportion the N fixed by the clover (assuming that the remaining N is taken up by the clover from soil N-pool)

5. For other legumes, see table I.1.

The biomass of legume is estimated by measuring total grass yield (above-ground production) and multiplying this by the percentage of clover.

The grassland yield can be measured/estimated directly (full harvest, vegetation samples, grass-plate measurements, grass height) or calculated through animal needs (ref) knowing the mean milk production (and/or growth) and the contribution of other forage and concentrates in the year.

The percentage of clover can be estimated by:

- visual observation (note that % of cover is in general higher than % of yield) or
- the "handful" method (taking a handful of grass and estimating the percentage of clover).
- Sample analysis (NIRS, cf Aurélie Grignard in Dairyman project) could be tested in experimental farms (compared with direct measurement of vegetation samples or the handful method)

Table I.1

N fixation calculation

for grassland legumes, kgN /ha

for white clover, *1.3 to take into account stolons and roots biomass
N Fixation = (DM Production * % clover * N rate in clover * fixation rate) *1.3

for orther grassland legumes
N Fixation = (DM Production * % legumes * legumes N rate * fixation rate)

For grain legumes kgN/ha

lupin :	74 kg N uptake / t production * fixation rate	
horse bean	59 kg N uptake / t production * fix rate	
forage peas	56 kg N uptake / t production * fix rate	
peas	35,7 kg N uptake / t production * fix rate	
french bean	13.3 kg N uptake / t production * fix rate	
dried bean	28 kg N uptake / t production * fix rate	

*production expressed in fresh harvested biomass

	fixation rate %	N p1000 g/kg DM
white clover	85	35
red clover	80	25
alfalfa	75	26
Vicia sp	80	28
Lotus sp	80	30
others	80	28
lupin	75	74
horse bean	75	59
forage pea	65	56
peas	65	35.7
french bean	30	13.3
french bean	30	28
soja bean	60	

I.3.2 Atmospheric deposition of N (worksheet Fgate other)

Atmospheric deposition is estimated using the most recent EMEP data[8].

I.4 Farm-gate balance for C

I.4.1 Data

A farm-gate balance for C is established using the mass flows (kg dry matter) recorded in the 'Fgate sheets' that are also used to establish farm-gate N and P balances.

I.4.2 Method

The procedure to calculate farm-gate C balance is similar to the method for N and P, as shown below. However, the interpretation in environmental system analysis is completely different. This is discussed below.

Inputs of C to a farming system are:

1. C in biomass imported with feed
2. C in organic matter imported with organic fertiliser
3. C in carbon dioxide captured by plants in plant tissues.

The outputs are:

1. C in milk and meat
2. C in organic matter exported with organic fertiliser
3. C in carbon dioxide emitted by respiration from carbohydrates of stored crops
4. C in carbon dioxide emitted by respiration from carbohydrates in animal excreta (composting)
5. C in methane emitted by fermentation from stored crops
6. C in methane emitted by fermentation and digestion of feed by cattle
7. C in methane emitted by fermentation from animal excreta (manure fermentation)
8. C in carbon dioxide emitted by respiration of soil micro-organisms in SOM turn-over

We can distinguish anthropogenic flows (no. 1 and 2 of inputs, and no. 1 and 2 of outputs) and flows driven by biological processes (no. 3 of inputs: C captured by crops, no. 3 and more of outputs: C respiration and fermentation).

For C, inputs to farms and C outputs to farming systems are reported, according to an approach similar to that used for N and P, that is, all inputs to the farms are recorded and summed. The capture of C in carbon dioxide by plants is estimated from crop yields plus an estimate of the C retained in crop residues. Crop C residues will differ for each crop and depend on the harvest method. C in biomass imported with feed and in organic matter imported with organic fertiliser is estimated by the mass of organic flows. The output of the farm-gate balance is the output in milk and meat and in organic matter exported with organic fertiliser (the anthropogenic flows).

[8] European Monitoring and Evaluation Programme (EMEP) www.emep.int

It is assumed that the C content in carbohydrates = 50% of the DM. Alternative values can be used when they are supported by a more refined analysis (e.g., referring to the relation between 'age' of organic matter and C content or personal measurements).

The surplus of the farm-gate C balance (input minus output) accumulates in the soil (sequestration) or is emitted (output flows 3 to 8). For an adequate judgment of C management on farming systems, the information on C surplus must be weighed in combination with data on C sequestration. This is different for C than for N and P. For N and P, high inputs and low outputs are considered a burden on the environment, and N and P surpluses are used mostly as an indicator of the quality of mineral management, in which reduction of surpluses indicates improved management. In contrast, a high C surplus is not necessarily considered a burden on the environment. A high C surplus is considered good when C is sequestered in the soil but not good when few of the C inputs are transformed into C leaving the farm in products due to losses by fermentation or respiration.

This difference in evaluation of farm-gate balances does not need to be a concern for the data collection. If all inputs and outputs are recorded, decisions on weighing flows in the evaluation of environmental effects can be taken later.

Agreement

1. C farm-gate balance = inputs (all) minus outputs (anthropogenic)
2. C content in carbohydrates of the DM = 50% unless more accurate data are available

I.5 Balances for agronomic and energy production on farms

In CANTOGETHER, export and inputs of (organic) mass flows can be related to crop or animal production, but also to energy production. Farms may also explore both activities: agronomic (crop and animal) production and energy production. To determine the inputs/outputs and balances of both energy production and agronomic production in the worksheets 'Fgate Plant', 'Fgate OrgFert' and 'Fgate Output', the flows can be recorded separately for both branches on a farm. Note that in 'Fgate Output' it is also possible to make a distinction between crops sold for consumption (human or animals) and crops sold for bio-energy.

SEVENTH FRAMEWORK PROGRAMME

Appendix II Energy use and energy production

II.1 Overview

Data collection on energy is focused on:

1. Non-renewable energy consumption
    a. Farm level: consumption on the whole farm (similar to farm N and P inputs)
    b. Farm components: consumption for animal groups and crops
2. Energy production, i.e.: production of energy that can replace non-renewable consumption

Data on non-renewable energy consumption (farm level and farm components) is collected in datafile: DWP2E.xlsx, worksheet Energy use.

II.2 Energy consumption on farm level

The data collection of energy consumption includes:

1. Direct use on the farm (fuel, electricity, gas)
2. Indirect use off-farm (i.e. energy required to manufacture and transport the inputs (fertilisers, concentrates, etc.), machines and buildings

II.2.1 Direct energy

Direct energy use includes use of fuel and electricity due to all on-farm operations, including the work done by others, i.e. colleagues or contractors (fuel consumption by contractors). Energy use should be corrected for use of work done for others. Private use does not belong to direct energy use of the farming system. It can be estimated using standard values. On many farms, however, energy use of the farmhouse and of the farm will be recorded separately.

> Direct on-farm energy use = fuel and electricity bought and used during the year – fuel and electricity used in the farmhouse + fuel and electricity used by contractors for the farm – fuel and electricity used by the farmer when working on other farms

II.2.2 Indirect energy

The use of indirect energy is estimated using standard values for the indirect energy that is invested in the manufacturing of a resource (e.g., water, fertiliser, feeds) in MJ per unit of the resource. Transport to the farm is also taken into account. Energy use of transport is estimated using standard values for transport per unit of resource per km and assuming an average distance for each region. The use of indirect energy can be calculated from the data used to estimate farm-gate balances for N, P and C. The results are expressed in MJ.

II.3 Energy consumption by farm components

Energy consumption can be attributed to several farm components, activities and production groups. In CANTOGETHER it is important to quantify the energy used for animal production and crop production separately. More specifically, the aim is to quantify energy use related to specific:

1. Animal groups
2. Crops, with a distinction between crops sold and crops used to feed animals.

Therefore, in the worksheet, data on energy are collected for crops grown and animals. Moreover, manure management has been added. Energy use is rarely recorded for specific activities on the farm; therefore, energy use is estimated from units that are related to energy use:

1. Category animals:
   Energy consumption is estimated from **the energy use of machines per hour times the number of hours per year that a machine is turned on**. This is done for the most important machines/activities. If more than one machine is used to carry out a task, their consumptions must be summed.
2. Category crops:
   For each crop the energy consumption is estimated as the energy use of an **activity per ha times the area** that is treated. This is done for the most important activities. Unspecified activities must be summed (e.g., spraying pesticides, soil tillage other than ploughing, such as harrowing).
3. Category manure management:
   Energy consumption is quantified by multiplying **the energy consumption of processing a m^3 of manure with the volume that is treated**.
4. Category other activities:
   Here, energy consumption not covered by the categories mentioned above can be recorded.

The estimates of energy use of farm components are probably not as reliable as the energy use at farm level. The sum of energy use of farm components can be compared to the energy use at farm level in worksheet 'Energy use' (row 533 to 538) to check the estimates of farm components. Large differences indicate problems in estimating energy use of farm components.

If possible, default values are used for the energy use of machines per hour per ha or m^3 of manure processed. The values are used only if they were available and considered reliable. If they are not given, you are requested to supply specific values for energy use. For most machines, technical data can be used that refer to power requirements under normal or intensive use. Values for fuel use of machines that are used for soil tillage should represent the relevant soil type (e.g., more energy is used for ploughing on heavy clay soil than on light sandy soil). For tractors, the energy used to perform a task may be recorded on the farm.

II.4 Energy production

Energy production by the sun, wind and/or fermentation is recorded by gauges. The quantity that is converted into a form used on the farm or by others is recorded, not total production. This quantity may be particularly low for heat.

II.5 Allocation

Energy used to grow crops may be attributed to animal production if the crops are used to feed animals but to crop production if the crops are sold. Sometimes energy used for a forage crop may benefit the growth of a subsequent arable crop. If so, it is uncertain whether the energy use should be attributed to the animal component or to the crop component.

Allocation decisions are not made during data collection. Data collection aims to deliver data that are suitable to support whatever decision is made during interpretation and analysis of the data. In chapter 8 of Verloop *et al.* (2012), general suggestions are made about allocation.

Appendix III Pesticides

A first step is to collect data on pesticide use at farm level and to indicate on which crops the pesticides have been used. That means that for more detailed analyses at crop level, additional information has to be collected. This approach is proposed to respect the main focus and aims of CANTOGETHER and WP2.

To estimate pesticide use, the names of the pesticides purchased and/or applied and the application rates should be known. For our purposes, we need names for pesticides that are short, distinctive, non-proprietary and widely-accepted. We propose to use trademarks, not systematic chemical names, which are rarely short and not convenient for general use.

A list with the most common names will be supplied. This can be used to fill in the data in worksheet 'Pesticides'.

In short the data structure will be:

Name of pesticide >> Amount purchased/applied at farm level (similar to farm-gate for nutrients) >> Crops on which pesticides are used.

Appendix IV Units and conversion factors

Energy: conversion to MJ - NL proposal	density	Energy content (Combustion value)		
	kg/l	MJ/l	MJ/kg	MJ/m^3
Heavy fuel oil (used in ships)		40.0		
Light fuel oil (heating of houses and buildings)		41.0		
Diesel fuel	0.83	35.3	42.5	
Petrol	0.79	34.0	43.1	
Propane	0.58	26.9	46.35	
Butane	0.85	38.9	45.75	
LPG, ca. 40% butane, 60% propane	0.67	30.8	46.0	
Natural gas				30
Benzine	0.73	32.4	44.4	

Electricity: 1 MJ = 0.278 kWh

Livestock unit - French proposal

Milking cattle	**UGB***
Dairy cow	1.0
Calf (male or female, less than 1 year)	0.3
Heifers 0-6 months	0.2
Heifers 7- 12 months	0.4
Heifers 1-2 years	0.6
Heifers 2-3 years	0.8
Heifers older than 3 years	1.0
Males 0-6 months	0.2
Males 7-12 months	0.4
Males 1-2 years	0.6
Males 2+ years	0.8
Males 3+ years, bull	1.0
Beef cattle	
Suckler cows	0.85
Heifers 0-9 months	0.3
Heifers 9-12 months	0.4
Heifers 1-2 years	0.6
Heifers 2+ years	0.8
Heifers 3+ years	0.85
Males 0 -9 months	0.3
Males 10-12 months	0.4
Males 1-2 years	0.6
Males 2+ years	0.8
Males 3+ years	1.0
Standard veal calves	0.12
Other veal calves	0.18

N and P fluxes

	Used in CANTOGETHER
Phosphorus (P) = phosphate (P_2O_5)/2.29	P