A practical manual to assess and improve farm performances

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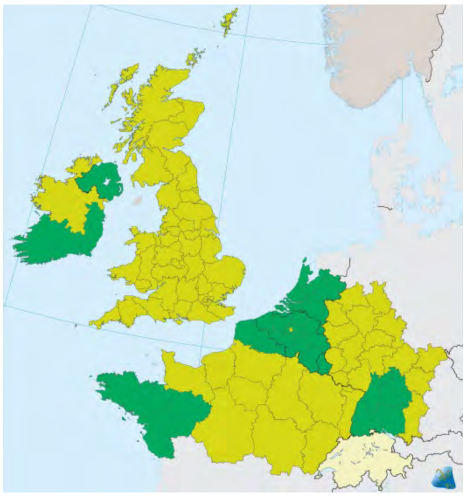
DAIRYMAN aims to strengthen rural communities in the regions of North-West Europe where dairy farming is a main economic activity and a vital form of land use. Dairyman is the acronym of Dairy Management. Through better resource utilization on dairy farms and stakeholder cooperation DAIRYMAN will lead to a more competitive dairy sector, stronger regional economies and an improved ecological performance with the rural area.

DAIRYMAN is a project in the INTERREG IVB program for North-West Europe (NWE) co-funded by the European Regional Development Fund. Under chairmanship of Wageningen University & Research Centre 14 partners in 10 NWE regions (dark green) covering 7 countries are cooperating.



INTERREG IVB North-West Europe

The INTERREG IVB North-West Europe (NWE) programme is a financial instrument of the European Union's Cohesion Policy. It aims to find innovative ways to make the most of territorial assets and tackle shared problems of Member States, regions and other authorities. Over seven years, from 2007 to 2014, the programme will invest € 355 million from the European Regional Development Fund (ERDF) into the economic, environmental, social and territorial future of NWE. The fund will be used to co-finance projects that maximize the diversity of NWE's territorial assets by tackling common challenges through transnational cooperation.

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List of Agronyms

AA	Agricultural Area
AES	Agro-Ecological Structure
BF	Belgium – Flanders
BW	Belgium - Wallonia
DM	Dry matter
FB	France – Brittany
FL	France – Pays de la Loire
FN	France – Nord Pas de Calais
FPCM	Fat-Protein Corrected Milk.
GE	Germany
IN	Northern Ireland
IR	Ireland
LU	Luxembourg
NL	The Netherlands
NVZ	No vulnerable zone
NWE	North Western Europe

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Introduction

The business of a dairy farmer is to supply society with dairy products in a way that provides him sufficient income and satisfaction. But he has to avoid farming practices hampering the rural area to deliver other valuable products, like clean drinking water, biodiversity, and attractive recreation facilities.

The socio-economic objectives of farmers change, as do the wants of rural societies. The prices of land, feeds, fuels and fertilizers change while innovations to support farming become available. Consequently, a farmer has to adapt his farming practices to the changing reality. In this context, DAIRYMAN aims to strengthen rural communities in the regions of North Western Europe (NWE) where dairy farming is a main economic activity and a vital form of land use. DAIRYMAN will lead to a more competitive dairy sector, stronger regional economies, and an improved ecological performance of the rural area. DAIRYMAN is a project in the INTERREG IVB programme co-funded by the European Regional Development Fund. The project is working at three levels: regional, commercial dairy pilot farms, and knowledge transfer centres.

The DAIRYMAN project involves 130 dairy farms in 10 regions of NW Europe cooperating to increase the sustainability of their farms from an economic, social and environmental point of view. A farm development plan was made for each of the farms involved in the DAIRYMAN network, based on a common, well-discussed structure. Experiences, failures and successes of these 130 try-outs have been used to write this manual, to be used by farmers and farm advisors in the participating regions.

The farm development procedure starts with an inventory of what is regarded as important by the region because a farm cannot be sustainable if it neglects the concerns of the rural population to which the farming family belongs. Besides, farmers should be aware that it can be financially attractive to cooperate with, for instance, nature organizations or drinking water companies. Chapter 1 of this manual provides information about regional objectives, regional legislation, and opportunities for cooperation with other users of the rural area.

Next, the advisor should make an inventory of actual farm facts and figures, needed to analyze and evaluate the functioning of the farm, both socio-economically and ecologically, and find the scope for improvements. How inventory and analyses can be done is the theme of Chapter 2. This of course is not the only right way to do so. Indicators chosen and analyses performed will depend on each study, objective, and context.

When the actual functioning of the farm and the scope for improvement are known, advisor and farmer should define the farmer's personal objectives. What income is sufficient and wanted? What is his limit of working hours per day or week, does his family want to go on holiday and for how long? What work does he prefer most? How robust should the farming system be? Chapter 3 helps to find and rank such personal objectives.

Knowing the functioning of the farm, the wants of the region, and the objectives of the farmer, the best fitting development strategy and related actions should be defined. Chapter 4 can help to do so.

PART I:

Objectives of the rural community

1. Objectives of the rural community and challenges

(F. Aarts)[1]

A farmer is part of the rural community. He contributes to its welfare by providing employment and income. The downside is that harmful emissions from dairy farming tend to be high, owing to low efficiencies in the use of fertilizers, feeds and energy. These inefficiencies are hampering the delivery of key public services, such as clean water, clean air and recreation facilities as demanded by society or other rural businesses.

The target of this chapter is to learn about the wants of the region in which the farm is located and about the environmental legislation. These should be taken into account in planning farm development.

For each of the DAIRYMAN regions two reports are available. The first describes the main environmental problems and the contribution of dairy farming to these problems. Farm development should focus on these problems. The second report describe how environmental EU legislation (Directives) was implemented as regional legislation. Legislation should be observed in farm development. Detailed, region-specific information can be found in these reports. The reports are summarized below.

1.1 Regional priority of environmental issues

The priority of environmental issues per region is ranked in Table 1. Nitrate in water has been ranked most frequently as an issue of high priority, followed by greenhouse gases (GHG) in air, biodiversity, and phosphate in water. Summed across all regions, ammonia emissions have the same priority ranking as pesticide pollution of water. Although in most regions soil erosion and soil fertility are ranked as having a low priority, both are ranked as having a high priority in at least one region (Nord Pas de Calais: erosion, Wallonia: fertility).

Table 1. Priority of environmental issues, ranked by the individual regions. 1 = lowest priority, 5 = highest priority.

	BF	BW	FB	FL	FN	GE	IN	IR	LU	NL	Total
Air quality											
Ammonia	4	3	3	3	2	3	2	2	1	5	26
GHG	4	5	3	3	1	2	5	5	2	3	33
Water quality											
Nitrate	5	5	5	4	4	3	2	1	4	3	36
Phosphate	4	2	3	2	1	2	5	3	3	5	30
Pesticides	3	4	4	4	3	1	1	1	2	3	26
Soil quality											
Erosion	3	3	2	1	5	2	1	1	3	1	22
Fertility	3	4	1	1	1	1	2	1	2	2	18
Biodiversity	2	3	3	4	3	4	3	1	4	2	29

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Table 2 indicates to which extent dairy farming contributes to these environmental issues. Differences in ranking can reflect differences in farming structures between regions but also differences in the share of dairy farming compared to other businesses in the region.

Table 2. Influence of dairy farming on regional environmental issues. This influence can be H = high, M = medium or L = low. For air and water quality the influence can only be negative (red). For soil quality and biodiversity the influence can be either positive (green) or negative (red).

	BF	BW	FB	FL	FN	GE	IN	IR	LU	NL
Air quality										
Ammonia	H	L	M	L	L	M	M	H	H	H
GHG	H	L	H	H	M	M	M	H	M	H
Water quality										
Nitrate	M	M	M	M	M	M	M	H	H	H
Phosphate	M	M	L	L	M	L	M	H	M	H
Pesticides	L	M	L	M	L	L	L	L	M	L
Soil quality										
Erosion	L	M	M	L	M	L	L	L	L	L
Fertility	L	H	H	L	H	L	M	L	M	L
Biodiversity	L	M	M	H	H	M	M	M	H	M

1.2 Current and future challenges for the dairy sector in NWE

The most effective way to improve environmental farm performance is to reduce the inputs of feed and fertilizers while maintaining or increasing milk production. Indeed, less purchased inputs will decrease costs and reduce the surplus of the nutrient balances. Part of the surplus will contaminate the environment with harmful N and P compounds. Improvement of farm performance requires a strategy.

How to develop and implement a strategy for improvement

Inputs can be reduced by improving the (re)cycling of N, P and C in 6 ways (Figure 1):

1. Reducing the feed needs of cattle
   (examples: less young stock, higher life-time milk production of cows)
2. Reducing the fertilizer needs of crops
   (examples: introducing rotations of temporary grassland and maize or including more legumes in grassland in order to reduce nitrogen fertilization needs, growing catch crops as green manure)
3. Increasing the yields of grassland and forage crops (home-grown feed)
   (examples: better soil structure, improved hydrology, better crop management)
4. Utilizing home-grown feed more efficiently
   (examples: reduction or stopping protein feed complementation under grazing, reduction of harvesting, conservation and feeding losses by better management and techniques)
5. Utilizing cattle excrements more efficiently as fertilizers
   (examples: preventing ammonia volatilization during manure storage, better timing and application of manures)

6. Adapting purchased products to the real needs
   (examples: during the grazing period no, or only low-protein, concentrates need to be fed in view of the high protein content of grass, N/P ratio of purchased fertilizers should be dependent on the N/P ratio in manures, and the N and P needs of the crops)

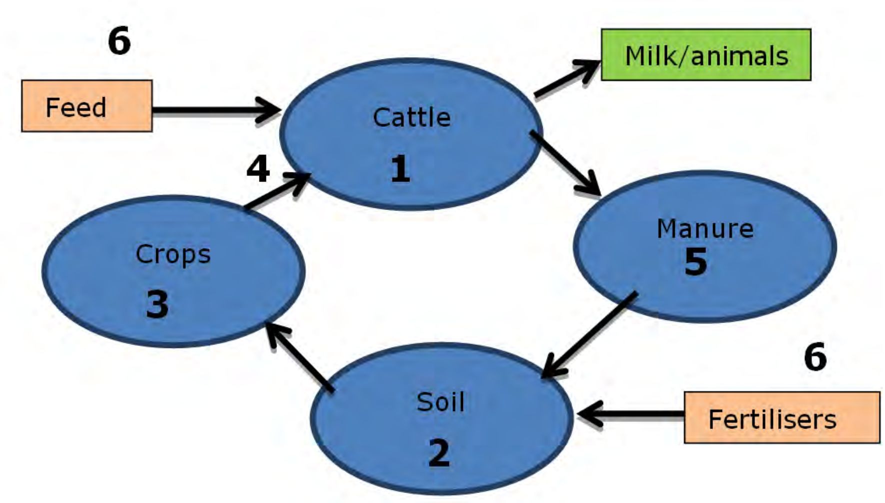

Figure 1. Fluxes of inputs within a farming system.

To implement the cycling strategy the farmer needs appropriate knowledge and self-confidence, technical and management tools and appropriate legislation.

Knowledge and self-confidence

Knowledge and self-confidence can be supplied by education and demonstration on pilot farms. Study groups in which farm figures are compared and discussed are very effective in detecting weak and strong points.

Technical and management tools

Technical tools can help to fine-tune fertilization or feeding or to improve the quality of manures and feeds. Management tools can help to provide and analyze farm data, to make a farm development plan, to support decisions and to reduce administration costs.

Appropriate legislation

Legislation to protect the environment is strongly measure-oriented with the government dictating the farmer how to do this. Mostly, measures are based on average circumstances. As a result measures are not always suited to farm-specific circumstances or actual weather conditions. Whenever possible, legislation should be goal-oriented, meaning, e.g., that a farmer has to meet maximum criteria for nutrient losses.

In this context of strategy implementation and providing appropriate knowledge and tools to help farmers to improve the sustainability of their farm, DAIRYMAN regions have cooperated to define and implement a farm development plan for each pilot farm in its network. The following chapters will develop the methodology to set up such farm development plans.

PART II:

Farm performances and farm development plan

2. Farm performances and farm development plan

2.1 Drawing up a Farm Development Plan (A. Grignard[2])

Farm development plans help farmers make strategic decisions that will improve their farm performance. A farm development plan is the result of three main steps (Figure 2):

1. Overview of the current farming system and its performance

This first step is essential to implement an appropriate strategy: before setting targets it is important to know the current level of performance and resources available. This step should help to define the ecological, economic and social limits, problems and constraints of the system, and should help to define the type of system and its behaviour and the opportunities for development. Therefore, three kinds of data are collected for each farm:

- Descriptive data: information on farm structure and management strategies (size of herds, land use, etc.) (See 2.2 Description of farm (A. Grignard)),
- Economic data: information on sources of revenues (milk, animals, crops and subsidies), operating cost (related to herds, grassland, crops, buildings and management), depreciation, interest and taxes (See 2.3 Economic data and performance (J. Boonen & M. De Haan)),
- Environmental data: information on amount and composition of inputs and outputs to calculate mineral balances (kg of N and P balance/ha), N and P efficiencies (ratio between output and input of nutrients at farm scale) (See 2.4 Mineral data and evaluation of environmental performance (S. Hennart)) and greenhouse gas emissions (See 2.5 Data on greenhouse gases (J. Oenema)).

Complementary to these data, qualitative information is essential to understand the farmer's motivation for the management practiced and decisions taken to provide a baseline for possible progress.

2. Definition of objectives taking account of current farm performance and geo-political context (See 3. Farmers' objective (E. CASTELLAN)).
3. Implementation of a strategy, sub-divided into several actions, to reach these objectives (See 4. Farmers' actions (A. GRIGNARD)). In conclusion, defining the farmer's objectives results in a combination of regional objectives, results of the farm (collected data), identifying assets/strengths and constraints, complementary discussion with the farmer (specific interest). Once objectives are defined, specific actions can be chosen to link farmer practice, farm assets and constraints and regional context.

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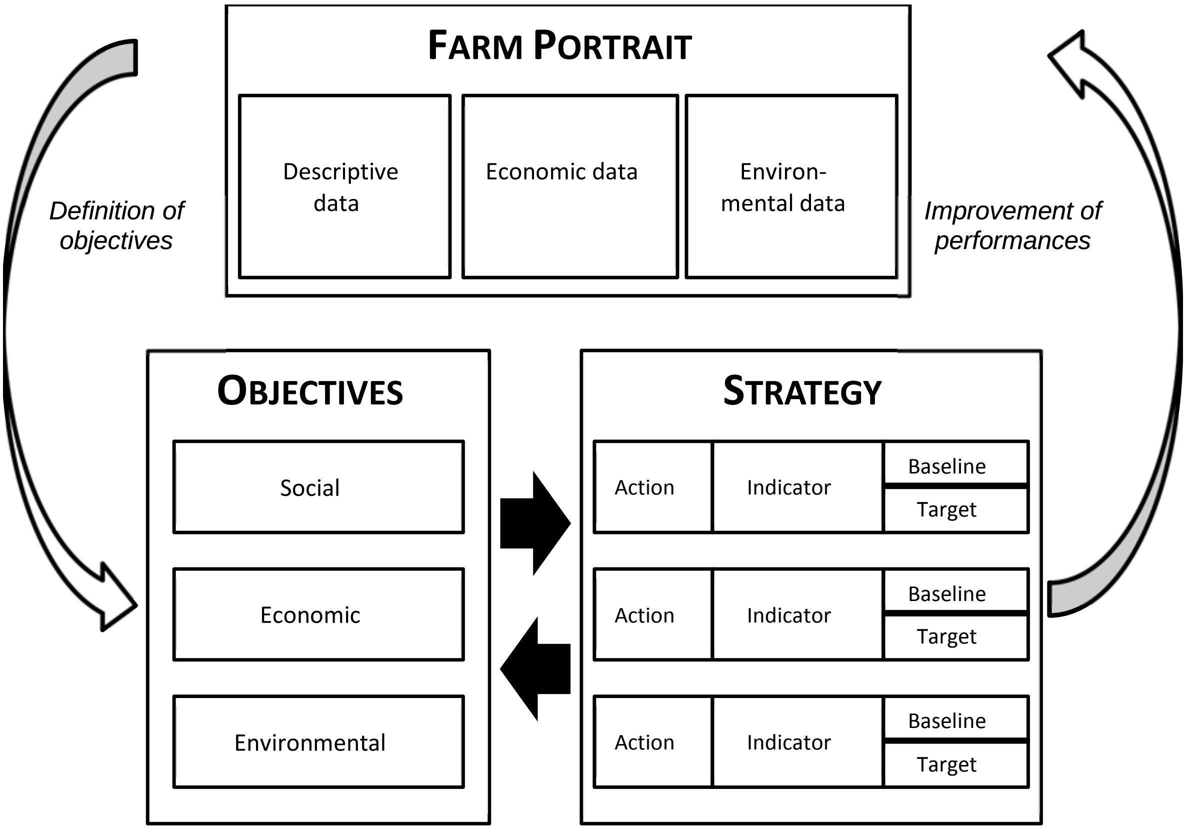

Figure 2. Schematic representation of the steps and elements required to establish a comprehensive and useful farm development plan.

2.2 Description of farm (A. Grignard)

To understand and properly interpret farm performance and efficiency it is essential to know the structure of the farm and its environmental context. Therefore, based on descriptive data and from interviewing the farmer, the current management and strategy implemented by the farmer can be determined. To be able to compare information between farms, collectors need to be supplied with a standardized Excel file. Data to be collected and the use of units and codes should be clearly defined to avoid ambiguity. If a specific indicator could provide a range of answers (for example type of soil), a list with representative answers has to be provided from which the collector selects. To ensure that the list of options is sufficiently comprehensive, a pre-survey of farms may be necessary.

2.2.1 Descriptive data required

Descriptive data can be categorized into five main topics: (1) farm strategy, (2) labour units, (3) soil-climatic zone, (4) land use and (5) livestock, each divided into sub-topics (Figure 3).

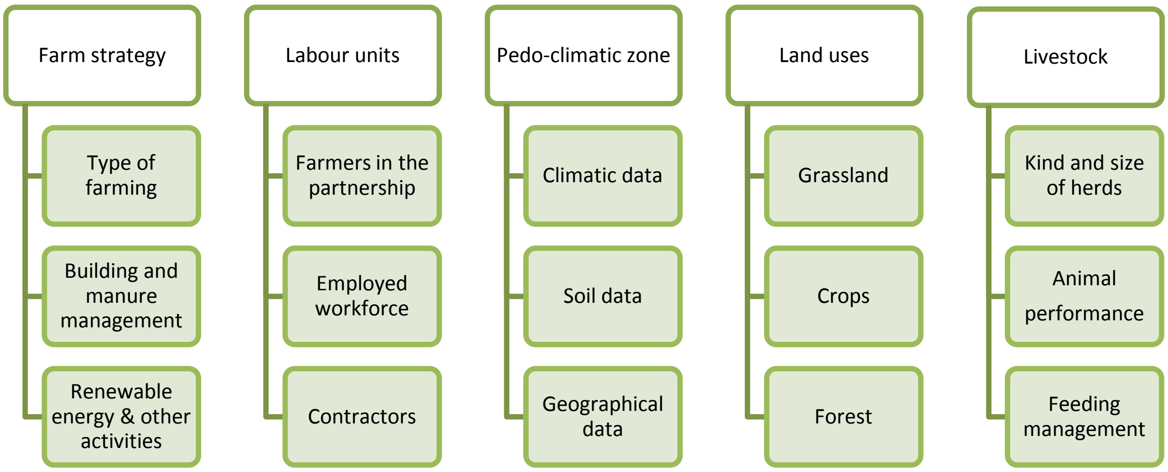

Figure 3. Scheme of descriptive data collected.

Each sub-topic gathers a set of information as presented in Table 3.

Table 3. Details about descriptive data to be collected for the different sub-topics.

Farm strategy	**Data required**
Type of farming	• Organic/conventional/in transition • On farm sales (kind of products and amount)
Buildings and manure management	• Building for dairy cows: type, number of places • Building for heifers: type, number of places • Milking system • Manure and slurry storage: capacity • Amount of manure product/year • Import/export of manure • Crop receiving manure (amount, date…)
Renewable energy and other activities	• Biogas production (kW, m³) • Photovoltaic panels (kW) • Wind turbine (kW)
Labour unit	
Farmers in the partnership	• Number of farmers, level of education • Number of hours worked per day, days for vacation • Successor identified? : Yes / No
Employed workforce	• Number of employees • Number of hours per year (per employee)
Contractors	• Type of work • Number of hours per year
Pedo-climatic zone	
Climatic data	• Average temperature (C°) and rainfall per year (mm)
Pedological data	• Type of soil (list)
Geographical data	• Longitude and latitude (dd°mm’) and altitude (m), GPS references
Land use	
Grassland	• Area of temporary and permanent grassland (ha) • Percentage of area used for own dairy enterprise consumption

Farm strategy	**Data required**
Crops	• Area of forage crops (maize, alfalfa, beet, etc.) • Area of commercial crops (wheat, triticale, barley, oat, spelt, etc.) • Percentage of area used for own consumption
Forest	• Area of land considered as forest
Livestock	
Type and size of herds	• *Dairy herds* (milk quota and production (real kg), milk quality (protein, lipid), breed, number of cows, heifers, calves, bulls for breeding) • *Suckler herds* (breed, number of cows, heifers, calves, bulls for breeding, beef for fattening) • *Other herbivores* (sheep, goats, horses,…) • *Pigs* (number for breeding and for fattening) • *Poultry* (number for fattening, laying hens)
Animal performance	• Calving-calving interval (days) • Age at first calving (months) • % of natural calving • Weight average (per age category) (kg)
Feeding management	• *Grazing strategy* (number of days/year, number of hours/day, area grazed by cows and/or cattle) • *Concentrate* (amount provide per cow per year, percentage of own production) (kg/cow/year)

In addition, current supplementary information about the farm is necessary to help define goals and actions (See 3 Farmers' objectives). Data required to interpret farm system and farmer's views and attitudes are therefore presented in Table 4.

Table 4. Additional data that may be useful to understand farm functioning and to highlight its specificity in comparison with other farms (Castellan E.).

FARM FUNCTIONING ELEMENTS	EXAMPLE OF DATA REQUIRED
Milestone of the farm	• Staff management, increase in size, new buildings
Land *(possible to have a table to fill in)*	• Agronomic potential: soil quality • Slurry spreading constraint: area, distance • Environment: water, houses…, • Land layout: distance to the farm, pasture accessible to cows… pasture adapted to cutting… • Land scheme ➔ **Assets and constraints of the land**
Dairy cattle management	• Reproduction: calving period, target age at first calving, reproduction problems, insemination (natural, AI) • Concentrates: type, management (only for corrections, complementation after calving…) • Forage stock management • Heifers: period inside, feeding, monitoring (weight) ➔ **Assets and constraints of dairy cattle management**
Others animal enterprises	• Importance related to dairy cattle • Feed type and origins • Work load consequences ➔ **Assets and constraints of other animal production**
Crop and pasture management	• Fertilizer management per crop (mineral and organic) • Pasture: number of grazing/cutting events, fertilizer application, yield, resowing, clover percentage • Cover crops: type, area, use (pasture, cutting), harvest or elimination • Pesticide application: per crop, number of treatments (insecticide, fungicide, herbicide) ➔ **Assets and constraints of crop and pasture management**

2.2.2 Indicators calculated

Some data can be used directly to quantify farm performance (for example calving interval, average weight) whereas other data have to be transformed before analysis. The degree of transformation and the form of expression of a parameter depend on the functional unit required. For example, a parameter can be expressed per labour unit, per cow, per hectare of agricultural area or per hectare of forage area, per amount of milk produced, etc. The selected option will depend on the nature of the data and on the point to be highlighted.

For example, the number of cows per labour unit can be calculated to gauge the workload but the number of cows per hectare is a more appropriate indicator to estimate the pressure on land (Figure 4).

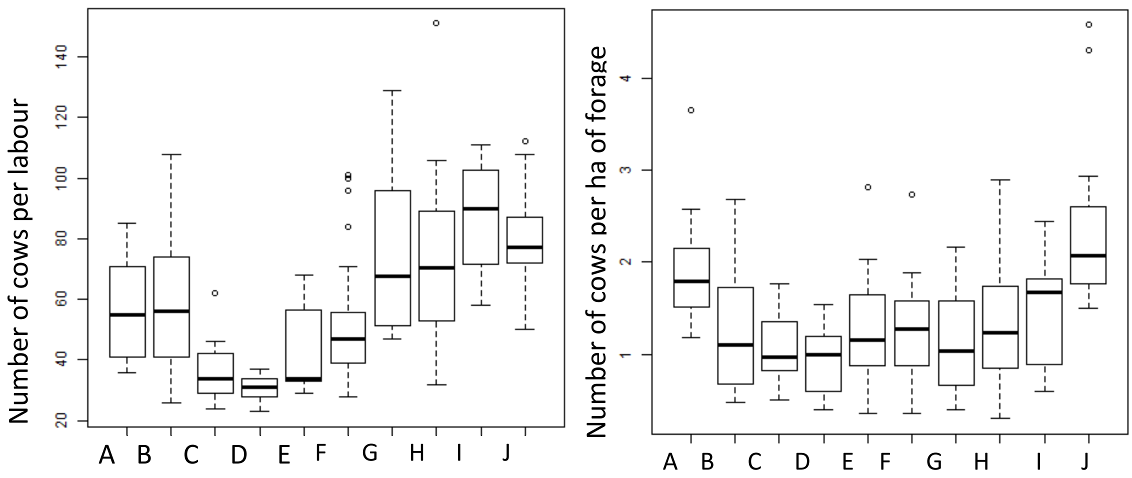

Figure 4. *Illustration of alternative representation of number of cows: (left) per labour unit to illustrate the workload or (right) per ha of forage area to illustrate land pressure (2009 and 2010 average).*

2.2.3 Illustration of results

Data can easily be presented descriptively in tables as averages with standard deviations. Boxplots (Figure 4), histograms (Figure 5, Figure 6) and pie charts (Figure 7) can also be used to illustrate the relative breakdown of a topic by region and/or its components.

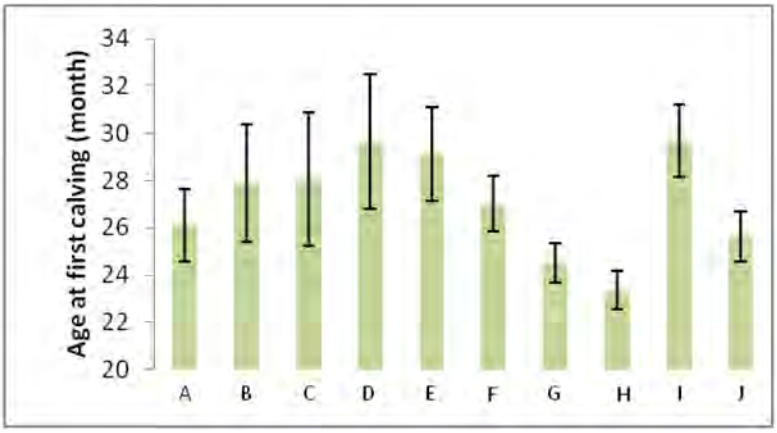

Figure 5. *Age at the first calving (average and standard deviation) per region (2009 and 2010 data).*

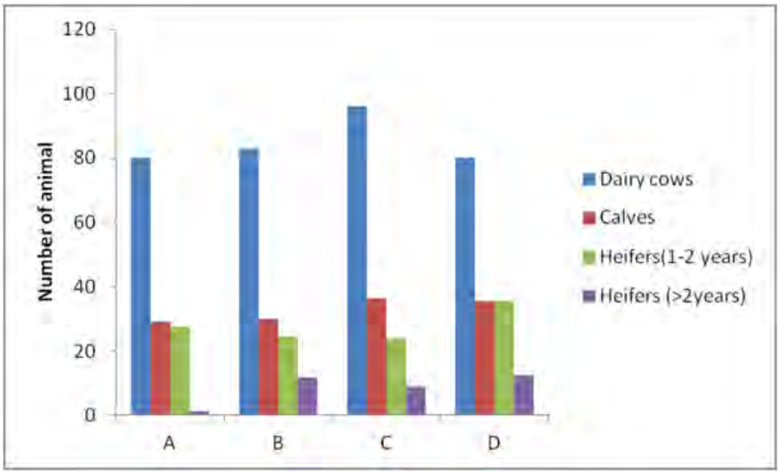

Figure 6. Breakdown of cattle according to age on some pilot dairy farms (2010 data).

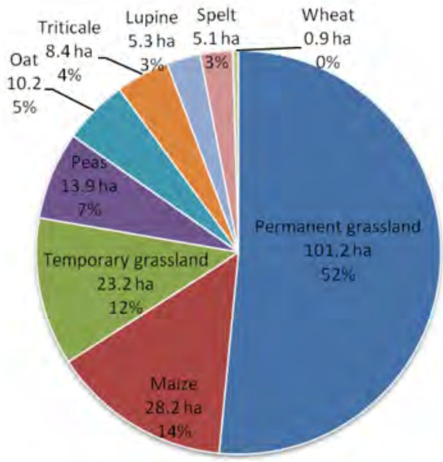

Figure 7. Breakdown of agricultural area of a DAIRYMAN pilot farm (2012 data).

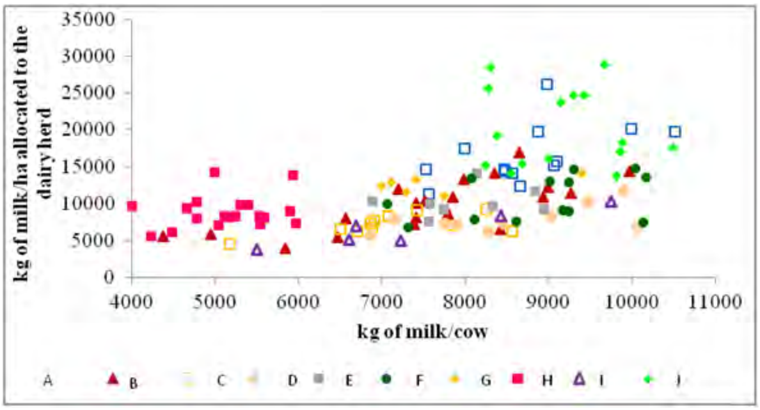

Figure 8. Relationship between milk production per cow and per ha, illustrating alternative expressions of degree of milk production intensification: per cow and per ha (2010 data).

2.3 Economic data and performance (J. Boonen[3] & M. De Haan[4])

DAIRYMAN aims to analyze sustainability of dairy pilot farms in North Western Europe. An important key factor in the sustainability of a farm is its economic viability. To withstand future challenges (market liberalization, environmental directives, etc.), economic performance of a dairy enterprise must be capable of remunerating the farmer for capital invested and work expended. Opportunities to increase farm income have to be identified and the economic impact of modified nutrient management has to be quantified. Analysis of a complete set of economic data from a farm and comparison with data from other farms, i.e. benchmarking, identifies options that are more profitable and sustainable in the long term. Therefore, collection of economic data from farms needs to be standardized to allow the data to be used for farm comparisons.

It is preferable to use a simple method to calculate and standardize economic performances. Systems to calculate costs vary between countries and, indeed, between accounting/bookkeeping firms. It is very difficult to find agreement on an acceptable standard system from existing systems. This means that as first principle, the priority of any system to quantify economic performance should be based on receipts and expenses. Deeper investigation of each of these categories can identify costs that are not expenses like depreciation, family labour, and calculated interest.

In some European regions dairy farms are mixed and produce other agricultural goods in addition to milk. This means that economic variables such as receipts and costs have to be allocated to the different enterprises on the farm so that only those that apply to the dairy enterprise can be identified. This action can be very simple, for example for concentrates or crop seeds, but it may also require estimations like the allocation of the farm buildings. As the different productions in a mixed farming system often are additional, it can be very difficult to delimit individual productions and errors add up the more costs and receipts are allocated.

2.3.1 Economic data required

The economic data are collected for one year, preferably from the 1st of January to the 31st of December, to avoid confounding comparisons as milk and input prices vary with time. Variation in stock numbers is not taken into account to simplify data collection and to avoid errors in estimations. The data can be categorized as follows: Descriptive data, Receipts and Costs. The detailed collected data presented in Table 5 *Opportunity costs* indicate the benefit that could have been gained from an alternative use of the same resource. It is a calculated rather than a real cost. Opportunity costs are calculated for family labour, land in property, own buildings and own machinery. These costs give a good indication of the labour costs in the economy of the different regions. These values have to be treated with caution as they are derived from estimates of workload which differ between regions. Also, the value of owned land on the farm is calculated and allows comparison between farms with rented and owned land.

Descriptive data

Some descriptive data are necessary to calculate the different economic indicators of the farm and to express costs. Most of this information is collected in the descriptive files. Only data directly needed in the economic spread sheet is collected.

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For example: the volume of milk produced and the fat and protein content of the milk are necessary to calculate the ***fat and protein corrected milk***[5] production of the farm; this indicator allows comparison of production between farms.

Receipts

In this category, farm receipts include: receipts from milk and selling animals, receipts from crop sales, and all public payments (subsidies). As the data cover only one year, special investment grants are not considered. The production of electricity from photovoltaic panels is not considered as an agricultural activity of the farm.

Costs

Categories of costs depend on the availability of accurate economic data. Exact annual expenses are known and grouped into six classes. See also Table 5. These six categories are: cattle-related costs, crop-related costs, building-related costs, operational costs, management-related costs, and annual taxes. The other costs are not necessarily annual expenses or it is hard to get the absolute value. There are no common rules for calculations developed for these costs in the DAIRYMAN project. These costs are collected as described below:

- *Depreciation* of machines, installations and buildings is calculated according to the regional rules.
- *Interest*: only real interest paid to the bank is included. Determining the exact amount of interest may be difficult: on family farms, private and professional business is linked and some farmers are reluctant to publish these data. For example, the purchase of land with a bank loan can be a private decision, but may affect farm management and economic performance.
- *Quota costs* are also recorded separately so that they may or may not be taken into account. Information on quota costs is not always very useful as the system of quota trading and determination of its price vary between regions.
- *Opportunity costs* indicate the benefit that could have been gained from an alternative use of the same resource. It is a calculated cost rather than a real cost. Opportunity costs are calculated for family labour, land in property, own buildings and own machinery. These costs give a good indication of the labour costs in the economy of the different regions. These values have to be treated with caution as they are derived from workload estimates that differ between regions. Also, the value of owned land on the farm is calculated and allows comparison between farms with rented and owned land.

5 FPCM = (0.337 + 0.116*fat% + 0.06*protein%) * kg milk production.

Table 5. Data collected for economic analysis.

CATEGORY	EXPLANATION
Receipts (€)	
Sold milk	Revenue after super levy
Sold animals	Culled cows, calves, dairy heifers, etc.
Public payments	Single farm payment, payment for disadvantaged area, agri-environmental payments, Other,…
Other revenues	Crop and forage sold, biogas energy sold,…
Costs (€)	
Annual expenses	
Cattle-related costs	Feed, breeding, health care, bedding, animals, exporting manure
Crop-related costs	Land rent, seed, chemicals, fertilizers, crop insurance
Building-related costs	Gas, water, electricity, maintenance, repairs, fire insurance
Operational costs	Contractor, paid labour, fuel, oil, maintenance machines & installations
Management-related costs	Administration, advisor, office, soil and feed analyses
Annual taxes	Cattle, land, buildings
Depreciation	Machines & installations, buildings
Interest	Interest paid to the bank
Quota costs	Milk quota rented, opportunity costs of the own quota
Opportunity costs	
Land in property	Calculated costs of land in property
Buildings and machinery	Calculated costs of machinery and buildings in property
Family labour costs	Calculated costs of family labour

Complementary data can be helpful to understand the economic results and to identify progress. All data presented in Table 6 are not necessarily available: some can easily be calculated.

Table 6. Additional data that may be useful to understand farm functioning relative to other farms.

FARM FUNCTIONING ELEMENTS	EXAMPLE OF DATA REQUIRED
Dairy part	Average milk price (€/1000 l) Produced milk compared to quota (and explanation if different) Milk quality: cells, butyric (origin of problems)
Meat part	Number of culled cows Number of dead animals (cow, heifer, calf) and reasons Average price (€/kg per category)
Costs and margins	Feed cost (produced forage, concentrates, bought forage) in €/1000 l Breeding costs (veterinarian, reproduction, technical monitoring…) in €/1000 l Gross margin for the dairy cattle (€/1000 l and €/ha forage) Forages: cost of seeds, fertilization, pesticides,…(€/ha) Crops : cost, for each crop, of seeds, fertilization, pesticides,…(€/ha)

2.3.2 Allocation of the data to the different farm enterprises

To compare performances of specialized and mixed dairy farms, all data collected for a mixed farm have to be assessed to determine which should be allocated to the dairy enterprise. There are different methods to allocate the annual receipts and costs. Some are more precise than others but could also need more time to get through. The methods should be adapted to each type of expense (Table 7). Some expenses like feed, crop-related costs etc. can be more easily and precisely allocated to each activity than other; expenses like water, electricity, fuel, management-related costs and interests cannot be allocated precisely and need a specific method to achieve a good estimation of allocated costs. Depending on the data, they can - based on the importance of dairy cattle – be allocated to other cattle on the farm or on the area used for dairy production.

In general, the data should be allocated in consultation with the farmer. The use of fuel for machinery, e.g., has to be discussed with the farmer and an estimation of the field work and consumption has to be made. This method is always based on estimation and errors are possible.

Table 7. Methods of allocation for different types of costs.

TYPE OF EXPENSES AND COSTS	PROPOSED METHODS OF ALLOCATION
Feed, breeding, animals, health care, bedding, exporting manure	Based on the use of the different components (concentrate) between the different types of animal (dairy cows, heifers, suckler herds, pigs…). Allocation of the other costs (breeding, animals purchased…) according to their use between the different animal sectors. If this is not possible, the allocation can be based on the % of livestock units (LU) of the different activities (less precise but adapted to farms with a marginal other animal activity)
Land rent, calculated costs of land in property (opportunity cost)	Based on repartition of area between dairy sector, commercial crops… (see example)
Seed, chemicals, fertilizers, crop insurance	Based on the use of the different components (seed, fertilizer…) between the different types of crops and grassland (see example). If this is not possible, the allocation can be based on the % of the area taken up by each activity (less precise but adapted to farms with a small area allocated to other activities than the milk sector).
Gas, water, electricity, fuel+oil	Needs specific methods using external allocation (distribution, sharing out)[of money, funds, time, tasks, work] ➔ cost allocated to the type of production (milk, meat, cereals…) of cost (€) or consummation (L or Kw) of water, fuel and electricity dedicated to the different types of activities. Example: mixed farm with a total electricity cost of € 3500; 400 000 l milk production, 35 livestock units (LU) for meat production (beef for fattening) and 50 ha of commercial crops External allocation for electricity: € 7/1000 l of milk, €3/livestock unit for meat, € 3.5 /ha commercial crops. Electricity cost allocated to dairy sector = € 3500 x [(7 x 400)/(7 x 400 + 3 x 35 + 3.5 x 50)] = 0.91 x 3500 = € 3185
Depreciation of buildings, maintenance, fire insurance	Based on the allocation of the depreciation of the different buildings used by the different activities of the farm If not possible, this can be based on the allocation of the area (m2) used for various activities
Depreciation, repairs and maintenance of machines and installations	The same method used to allocate water, electricity and fuel can be used to allocate the cost of machinery. To avoid the problem of the different level of use of a contractor between farms, it is worth to globalize all costs dedicated to mechanization (fuel, oil, repairs, contractor, maintenance, depreciation) before allocating total mechanizations cost of the farm. It needs external allocation of cost of mechanization (/1000 l milk, /ha commercial crops…) based on specialized farms. A second method can be based on the % of the area of each activity but this is only suitable for farms with a small area used for other activities than the milk sector.
Management-related costs, annual taxes	Based on the part of the farm receipts resulting from the dairy enterprise
Interest, building and machinery opportunity costs	Based on the part of the permanent farm capital dedicated to the dairy enterprise If impossible, this can be based on the part of the farm receipts resulting from the dairy enterprise
Paid labour, family labour costs (opportunity costs)	Based on family and paid labour dedicated to dairy activities
Single farm payment	Based on the proportion of the area used for the dairy sector, commercial crops…
Payment for disadvantaged area, agri-environmental payments…	As this type of payment is usually dedicated to a specific area of the farm (grassland, etc.), the allocation over activities should be adapted to each situation.

Example A: Allocation of area
Mixed farm with grassland (80 ha), crops (10 ha wheat, 10 ha maize), suckler herd (20 LU) and dairy herd (80 LU).

	Dairy	Other (crops + suckling)	Remarks
Wheat	0 ha	10 ha	Total wheat sold
Maize	10 ha	0 ha	Maize only fed to dairy cows
Grassland	80/100*80 ha = 64 ha	16 ha	Grassland allocation calculated by the importance of dairy livestock units

Example B: Allocation of fertilizer costs
Mixed farm with grassland (80 ha), crops (10 ha wheat, 10 ha maize), 50 dairy cows
Total fertilizer costs: € 10,000 (10,000 kg N)

	Dairy	Crop production	Remarks
Wheat	€ 0	€ 2000	2000 kg N for 10 ha wheat Total wheat sold
Maize	€ 1000	€ 0	1000 kg N for maize Maize only fed to dairy cows
Grassland	€ 7000	€ 0	Grassland for dairy cows

Example C: Allocation of electricity costs
Mixed farm with total electricity costs of € 3500; 400 000 l milk production, 35 livestock units for meat production (beef for fattening) and 50 ha commercial crops
External allocation for electricity: € 7 /1000 l milk, € 3 /livestock unit for meat, € 3.5 /ha commercial crops.
Electricity costs allocated to dairy sector = € 3500 x [(7 x 400)/(7 x 400 + 3 x 35+3.5 x 50)] = 0.91 x 3500 = **€ 3185**

2.3.3 Calculation of income and other economic indicators

The collection of gross data (description, receipts and costs) allows a multitude of economic and performance indicators to be calculated, depending on the question to be answered. Allocation of the data allows separate calculation of the economics of both the whole farm and the dairy business of the farm.

Farm level:

$$\textbf{Gross Margin farm} = \textbf{Receipts} - \textbf{Annual expenses}$$

$$\textbf{Farm Income per labour unit} = \frac{Receipts\ - Annual\ Expenses\ - Depreciation\ - Interest}{Family\ Labour\ Units}$$

$$\textbf{Dependency on subsidies} = \frac{Public\ payments}{Receipts\ - Annual\ Expenses\ - Depreciation\ - Interests}$$

$$\textbf{Efficiency of the farm (\%)} = \frac{FARM\ Income}{Revenues}$$

Dairy enterprise of the farm:

$$\textbf{Labour productivity} = \frac{Milk\ production\ (kg\ FPCM)}{(Family\ Labour\ Units)_{dairy}}$$

$$\textbf{Income}\ (\text{€ per 100 kg FPCM}) = \frac{(Receipts\ - Annual\ Expenses\ - Depreciation\ - Interest\ )_{dairy}}{\frac{Milk\ production\ (kg\ FPCM)}{100}}$$

$$\textbf{Family Labour Income} = \frac{(Receipts - Annual\ Expenses - Depreciation - Interest\ )_{dairy}}{(Family\ Labour\ Units)_{dairy}}$$

2.3.4 Presentation of the results in view of the targets

Cost and revenue analysis

Farmers aim to decrease production costs to increase farm income. Comparison of production costs with other individual farms is very interesting to detect weaknesses in their own farm management. The data of the individual pilot farms can be presented in tables and the average value and the value for the 25% best farms can be added (example in Table 8).

To judge individual farm performances as regards production costs, it is important to analyze the results with the same typology based on:

- The combination of production. For example, the targets of specialized dairy farms and farms with a combination of dairy production and commercial crops could be different.
- The level of milk production per ha dedicated to dairy production (more or less intensive system).
- The type of forage system: parts of grass and maize, part of pasture and harvested fodder in the cattle diets ...

Table 8. Example of farm data comparison to detect weaknesses and strengths of a farm.

Data	**Farm X05**	**Farm X06**	**Ø Farms**	**25% best farms**
Feed costs €/100kg FPCM	8	4	7	5
…	…	…	…	…
Income	11	14	9.5	15

Data can be presented in tables and results can also be presented in figures, for individual farms or per group of farms with a similar structure, or from the same country or region in which case the average can conceal a wide variation between systems.

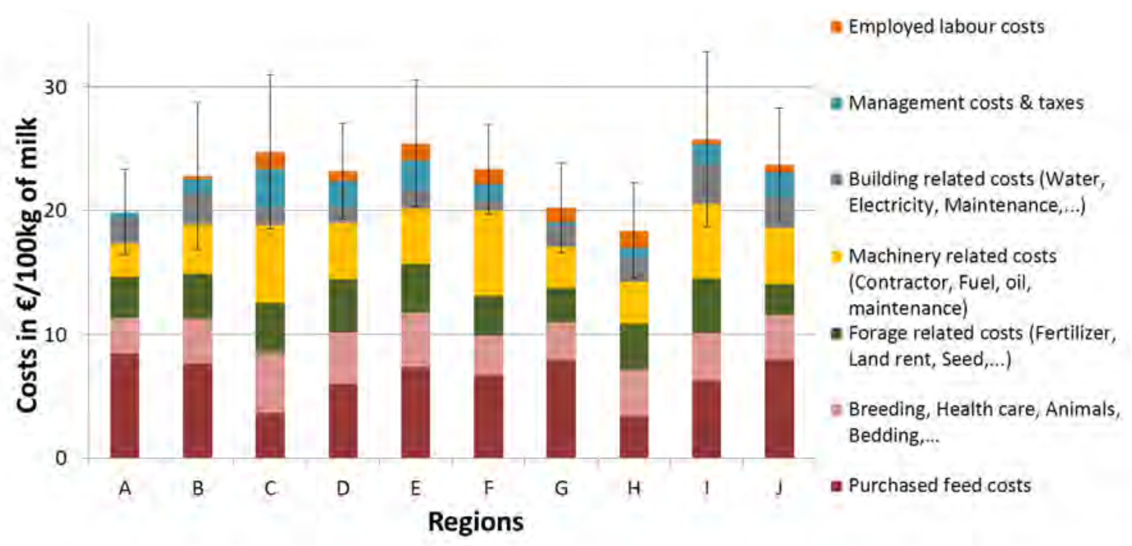

Figure 9. Total annual expenses for milk production (2010) of pilot farms in the different DAIRYMAN regions.

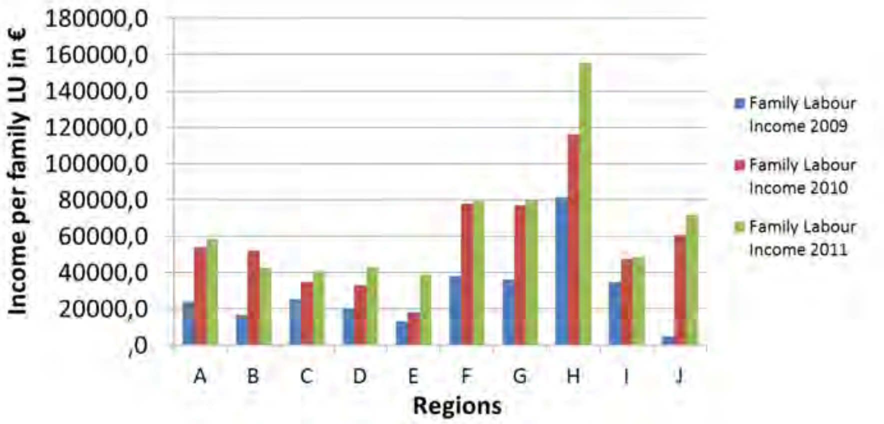

Figure 10. Comparison between income in 2009 and 2010 in the different DAIRYMAN regions.

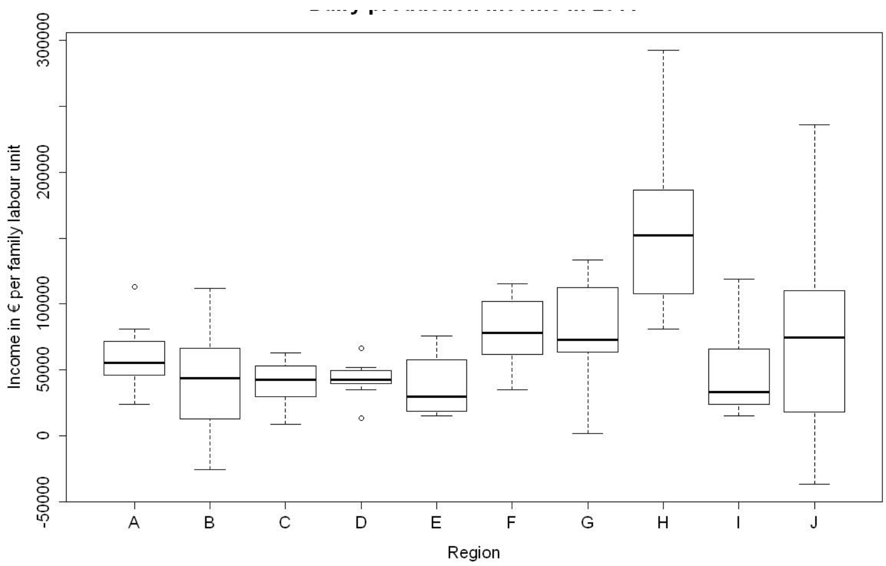

Figure 11. Family labour income (2010) in the different DAIRYMAN regions.

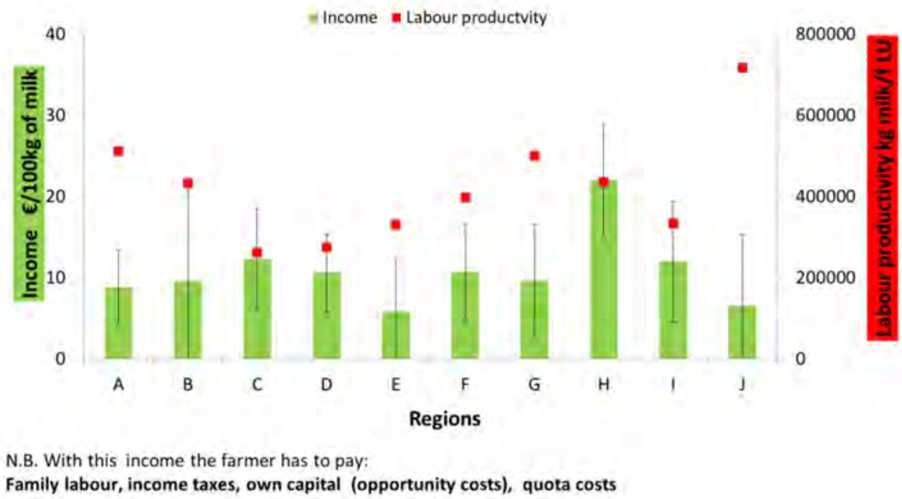

Figure 12. Income and family labour productivity of the pilot farms from the different regions involved in the DAIRYMAN project (2010).

2.4 Mineral data and evaluation of environmental performance (S. Hennart)[6]

The mineral balance of a system takes into account the difference between input and output at the system scale and characterizes the quantity of minerals lost or immobilized within the system. Generally, the elements taken into account are nitrogen, phosphorus and potassium but sometimes also other elements, such as carbon. These balances can be quantified at different levels, depending on the objective of the study, e.g. farm level, soil level, a specific production level.

The system can be considered as a black box and the fluxes between the different components of this black box are not analyzed. As an example, the exchange of organic manure between the cattle and the crop component of the farm is taken into account if the dairy production system is subject of the analysis but not if the whole farm is considered as the system.

2.4.1 Data required

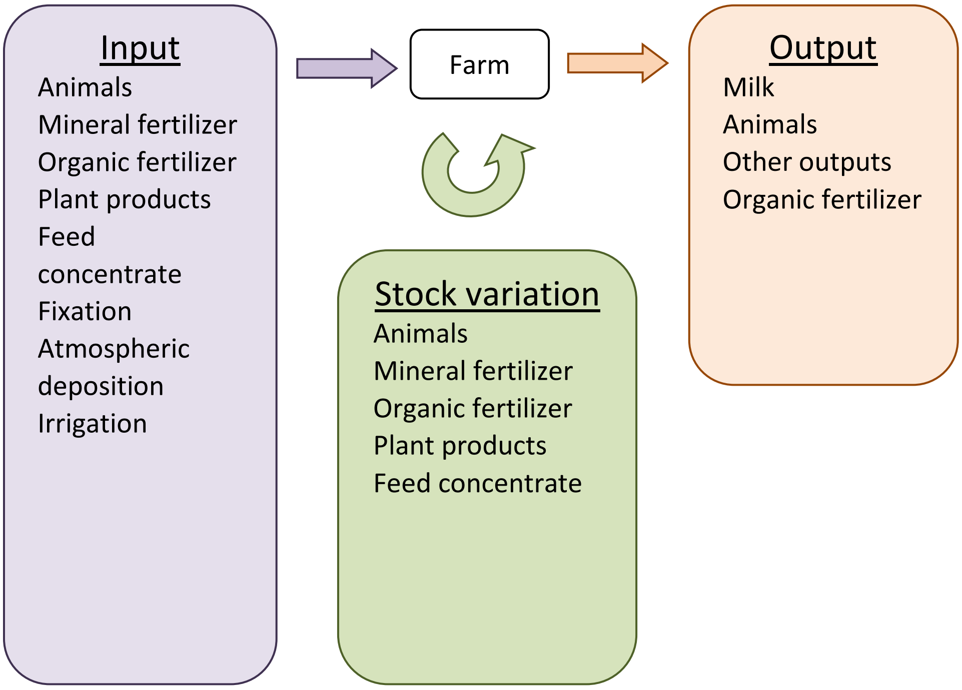

Figure 13. Data used to calculate the mineral balance.

The data required to calculate the mineral balances are grouped into three categories: INPUT, OUTPUT and STOCK VARIATION.

The inputs are the elements that are mobilized to produce the outputs. The outputs are the products exported outside the farm. Stock variation is the difference in the amount of an element present on the farm before and after the period considered. *As an example, a stock of mineral fertilization present from the last period and valorized during the study period needs to be taken*

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into account as input whereas a stock of feed concentrate not eaten by the cows is not valorized to produce milk and therefore needs to be subtracted as output. Each item of the three categories is detailed in Table 9*,* Table 10 *and* Table 11*.*

Table 9. List of the inputs to calculate the mineral balance at farm level.

INPUTS		
Animals	I_{Ani}	All categories of each type of animal: dairy cows, calves, heifers, suckling cows, pigs, poultry … with their weight (Annex II – NUTRIENT VALUES)
Mineral fertilizer	I_{MF}	Total amount of mineral fertilizer bought
Organic fertilizer	I_{OF}	Total amount of organic fertilizer imported
Plant products	I_{PP}	Purchase of forages, cereals, …
Feed concentrate	I_{FC}	Purchase of concentrate for animal feeding
Fixation	I_{Fix}	Symbiotic fixation by legumes
Atmospheric deposition	I_{AD}	Deposition of an element from the atmosphere (rain), depending on the region
Irrigation	I_{Ir}	Import of mineral elements by irrigation water

Table 10. List of the output factors to calculate the mineral balance at farm level.

OUTPUTS		
Milk	O_{Milk}	Milk sold to the dairy cooperative, or directly, transformed or not
Animals	O_{Ani}	Animals sold or dead
Other outputs	O_{OO}	Sold or exported material (straw, forage, cereals …)
Organic fertilizer	O_{OF}	Organic fertilizer exported from the farm

Table 11. List of the change in stock taken into account to calculate the mineral balance at farm level.

STOCK VARIATION		
Animals	SV_{Ani}	Taking into account the growth of the animals. Difference between the animals present at the beginning and at the end of the study period with their weight
Mineral fertilizer	SV_{MF}	Difference between mineral fertilizer present at the beginning and at the end of the study period
Organic fertilizer	SV_{OF}	Difference between the amount of organic fertilizer present at the beginning and at the end of the study period
Plant products	SV_{PP}	Difference between the plant products (cereals, straw …) present at the beginning and at the end of the study period
Feed concentrate	SV_{FC}	Difference between the feed concentrates present at the beginning and at the end of the study period

2.4.2 Indicators calculated

The main indicators are the balance of the single mineral elements and their use efficiency. Balance and efficiency are calculated in the same way for each element.

The stock variation is the difference between final stock and initial stock.

The mineral balance is the difference between input, output and stock variation.

$$Mineral\ balance = \sum Input - \sum Output - \sum Stock\ variation$$

The efficiency is the ratio between the production and the input needed for this production.

$$Efficiency = \frac{(O_{Ani} - I_{Ani} + SV_{Ani}) + O_{Milk} + O_{OO}}{(I_{MF} - SV_{MF}) + (I_{OF} - SV_{OF} - O_{OF}) + (I_{FC} - SV_{FC}) + (I_{PP} - SV_{PP}) + I_{Fix} + I_{AD} + I_{Ir}}$$

The above requires two explanations. First, the weight of the animals is changing continually but only sold dry cows and the replacement of the heifers are taken into account in the calculation of net meat production. Second, the output of organic manure is considered as a negative input because it is not a target of production, such as milk or meat. The inputs are not directed to produce organic manure since it is a by-product of the production of other products.

2.4.3 Illustration of results

Results can be presented either to describe a balance within the farm or as a comparison between farms.

Figure 14 is an example of a farm balance. The inputs and outputs are presented on the left and right hand side of the graph, respectively. The balance is the difference between the two parts of the graph and the most important sources of input or output are easily seen. Comparison with averages for similar farms or for farms from other regions identifies farms/regions that use nitrogen most effectively (Figure 15). For example, farms B and H have the highest (best) and farm F has the lowest (worst) mineral balance. On closer examination of the data, taking account of absolute levels of input and output, farms A and I (Figure 14), for example, have the same balance but the level of input and output for farm I is higher than that for farm A; this means that the nutrient use efficiency on farm I is higher than on farm A.

The relationship between descriptive parameters and mineral balance can also be established, e.g., between milk production and nitrogen balance (Figure 15), but also comparisons of the N balance between farms should integrate elements of typology, especially for N balance / ha AA, as:

- The part of commercial crops (% ha commercial crop/ha AA). Commercial crops export a lot of nitrogen whereas much lower quantities are exported with animal products (milk, meat). The

Mineral N balance of farms that combine milk production and crops is automatically much lower than that of a specialized dairy farm (at the same level of intensity).

- The level of litres of milk produced /ha allocated to dairy production. The less intensive systems (such as organic farming) tend to have a lower level of mineral N/ha (in relation with lower inputs).

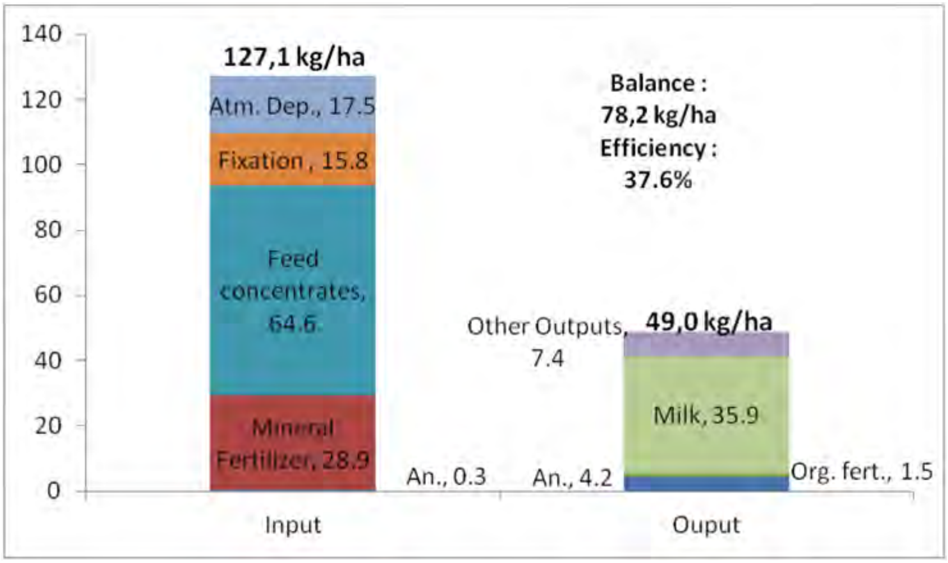

Figure 14. *Example of the nitrogen balance for a farm, expressed in kg nitrogen per hectare. Atm. Dep: atmospheric deposition, Fixation: symbiotic fixation, An.: animals, Org. fert.: organic fertilizer.*

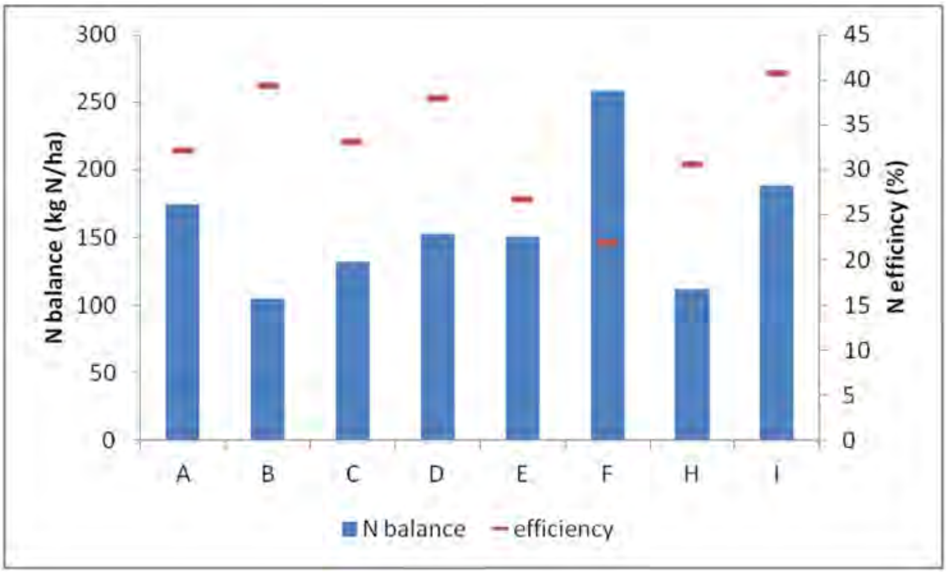

Figure 15. *Example of the nitrogen balance (kg/ha) for different types of farms.*

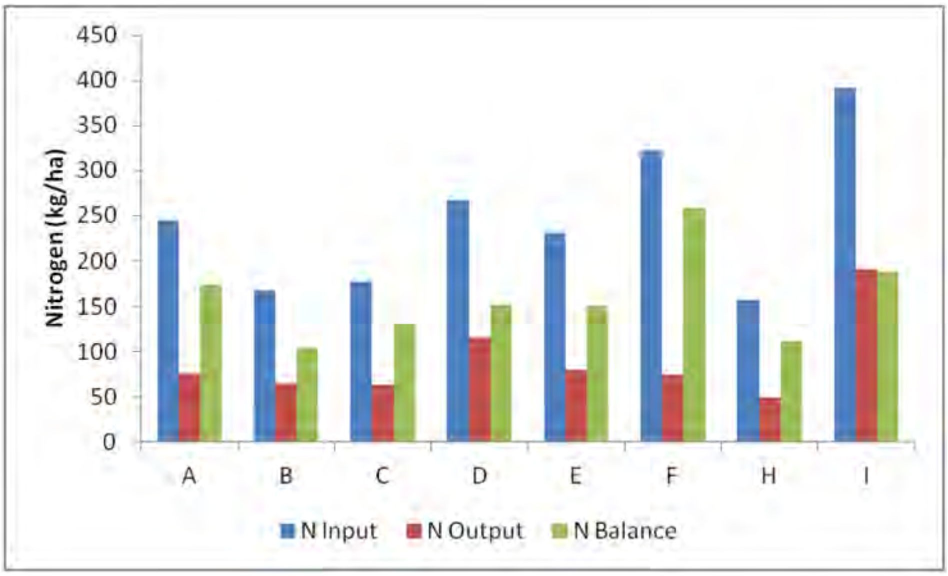

Figure 16. Example of nitrogen balance (kg/ha) and efficiency (%) for different farms.

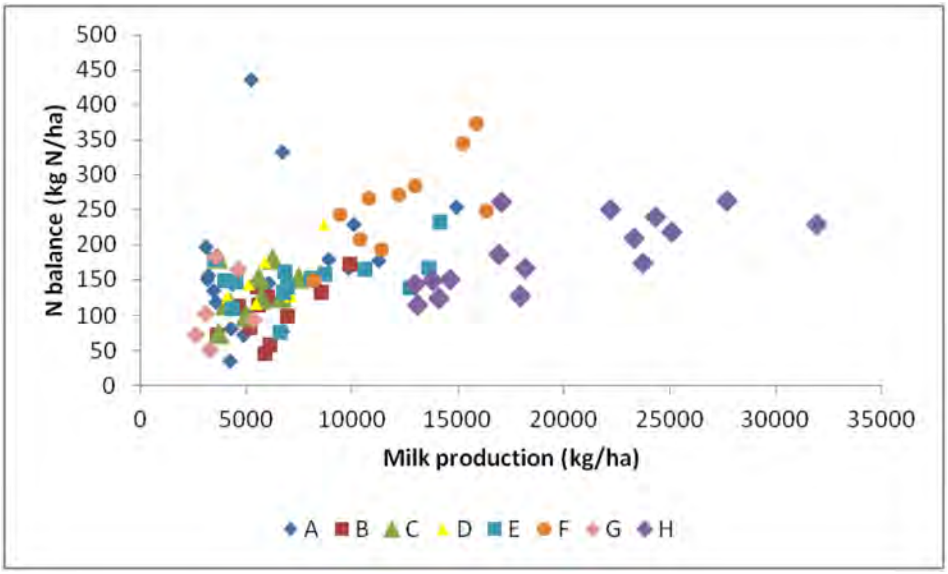

Figure 17. Example of the relationship between milk production (kg/ha) and nitrogen balance (kg/ha) for different types of farms.

2.5 Data on greenhouse gases (J. Oenema[7])

Worldwide, there is increasing interest in greenhouse gas (GHG) emissions. The Intergovernmental Panel on Climate Change (IPCC) has set up guidelines for the calculation of GHG emissions. These guidelines have been used to calculate emissions regionally. A common methodology has been developed in DAIRYMAN to calculate GHG emissions at FARM level, based on the IPCC guidelines 2006 (Tier 2). The tool is called **GHG DAIRYMAN Calculator**. The system boundary for GHG emissions is defined as 'Cradle to farm gate' (the so-called 'on farm' and 'off farm' emissions). The tool is a

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transparent Excel file, is easy to use, and includes details on calculations within the tool. Reference to appropriate page or table numbers in the IPCC manual 2006 is made if more background information is needed. Currently, the tool is suitable for dairy farming and (a part of) arable farming. For mixed farming systems, it is advised that only the part of the farm associated with dairying is considered, allocating area and nutrient flows, appropriately.

2.5.1 GHG data required

Data required for the GHG DAIRYMAN Calculator can be categorized into five main topics: farm balance, land use, livestock, manure and energy. Table 1 shows a list of the data required

Table 12. Details about required data.

FARM BALANCE	DATA REQUIRED
Purchased organic materials	• Sewage sludge, animal manure, compost (kg N) • Bedding materials (kg N)
Purchased feed	• Total amount of concentrates (ton products) • Specification of concentrates from cereals (wheat, barley, oat, corn etc.), rape, soya and other (ton products) • Total amount of by-products (ton dry matter) • Specification of by-products from fresh beet pulp, pressed beet pulp, dehydrated beet pulp and other (ton dry matter) • Total amount of forages/roughages (ton dry matter)
Purchased mineral fertilizer	• Nitrate fertilizer (kg N) • Ammonium fertilizer (kg N) • Urea fertilizer (kg N, ton products) • P_2O_5 fertilizer (kg P_2O_5) • K_2O fertilizer (kg K_2O) • Limestone fertilizer (ton) • Dolomite fertilizer (ton)
Export	• Home-produced animal manure (kg N)
LAND USE	
Grassland	• Area with and without clover (ha) • Grassland age • Yield of renewed grassland (dry matter) • Clover in grassland (fraction) • Increase and decrease soil C stock (ton C per ha)
Crops	• Hectare forage crops (maize, alfalfa, beet, etc.) • Crop residues (kg N per ha) • Harvest method (% of N of crop residues removal) • Increase and decrease soil C stock (ton C per ha)
Crop rotation	• Hectares converted from grassland → arable and arable → grassland • Soil Organic Carbon levels in grassland and arable land in rotation (ton C per ha)
Peat/organic soils	• Surface area (ha) • C loss (ton C per ha)

FARM BALANCE	DATA REQUIRED
LIVESTOCK	
Dairy herd	• Average number of cows and young stock • Average weight of cows and young stock (kg) • Live weight gain of dairy cows and young stock (kg per head per day)
Milk production	• Milk production (kg) • Protein and fat content (%)
Feeding management	• Digestibility of feed for cows and young stock (%) • Crude protein concentration in feed for cows and young (g per kg DM)
MANURE	
Manure management system	• Specify the manure management system for cows and young stock as fraction (e.g. pit storage, solid, lagoon, grazing) • Methane conversion factor for each manure management system (can be derived from existing tables)
ENERGY	
Electricity	• Milking (kWh per 1000 l milk) • Crops (kWh per ha)
Fuel	• Crops (l per ha) • Grassland and maize land (l per ha)

2.5.2 Indicators calculated

Figure 1 shows an example of results of GHG emissions from a dairy farm, distinguishing between 'on farm' and 'off farm' GHG emissions. 'On farm' comprises 4 components: animal, manure, soil and energy use. GHG emissions can be expressed in the unit of the source: kg CH_4 ha^{-1}, kg CO_2 ha^{-1}, kg N_2O ha^{-1} and/or as kg CO_2-equivalent (eq.) per ha. To aggregate the unit source to $CO_{2\text{-eq}}$ we used gwp-100y according to IPCC (2007). To calculate kg CH_4 in CO_2_eq we used the formula:

$$kg\ CO2 - equivalent\ = kg\ CH4 * 24$$

N_2O to kg CO_2 is converted as follows:

⇨ $$kg\ CO2 - equivalent\ = kg\ N2O * 298$$

Another indicator is to express the GHG emissions as kg CO_2-equivalent per ton milk. Both indicators, per ha or per ton of milk, can be used to compare GHG emissions from dairy farming systems.

Table 13. Example of output from the GHG DAIRYMAN Calculator.

	unit	kg product	kg CO_2-equivalent		
			ha^{-1}	$(ton\ milk)^{-1}$	%
ON FARM					
ANIMAL					
Methane	kg CH_4 ha^{-1}	352	7390	413	52
MANURE					
Methane	kg CH_4 ha^{-1}	110	2315	129	16
Direct N_2O	kg N_2O ha^{-1}	0.9	277	15	2
Indirect N_2O	kg N_2O ha^{-1}	1.2	351	20	2
SOIL					
Direct N_2O	kg N_2O ha^{-1}	6.8	2024	113	14
Indirect N_2O	kg N_2O ha^{-1}	2.2	639	36	4
CO_2	kg CO_2 ha^{-1}	0	0	0	0
ENERGY USE					
Electricity	kg CO_2 ha^{-1}	685	685	38	5
Fuel	kg CO_2 ha^{-1}	538	538	30	4
TOTAL ON FARM GHG			**14218**	**795**	100
- from CO_2			**1223**	**0**	9
- from CH_4			**9704**	**542**	68
- from N_2O			**3291**	**184**	23
OFF FARM (production and transport)					
Imported fertilizer					
- CO_2	kg CO_2 ha^{-1}	327	327	18	10
- N_2O	kg N_2O ha^{-1}	1.1	322	18	10
Imported feed	kg CO_2 ha^{-1}	2652	2652	148	80
TOTAL OFF FARM GHG			**3301**	**184**	100
TOTAL GHG			**17519**	**979**	

2.5.3 Illustration of results

The data from (a) single farm(s) can be presented in tables similar to Table 1. Results of single topics (e.g. total GHG per ha, total GHG per ton milk, contribution of different sources CH_4, N_2O and CO_2) from farms in different regions can be illustrated in graphs such as in Figure 18 to Figure 21.

Potential targeted improvement in GHG emissions on dairy farms requires identification of the most likely means of reducing emissions and, hence, where these improvements can be made. These can be identified by looking at relations between GHG emission among farms and/or regions and farm structure and/or management e.g. Figure 22 to Figure 25.

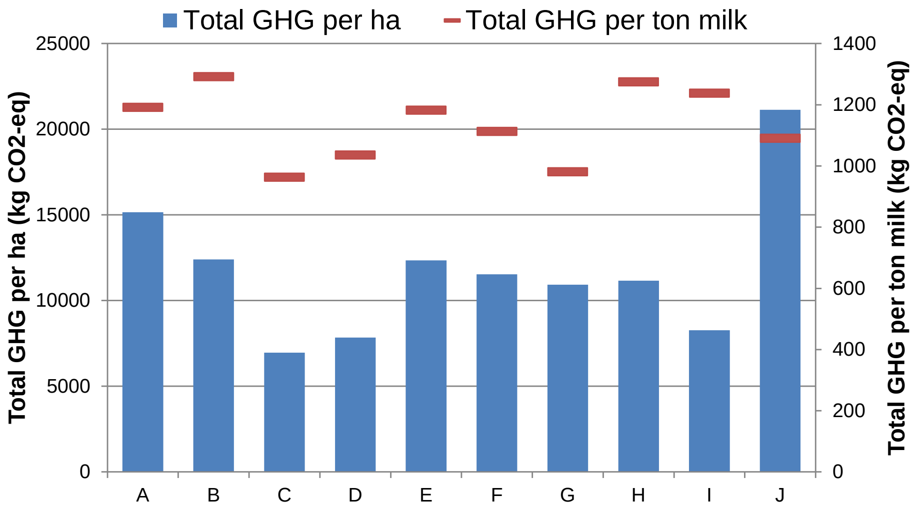

Figure 18. *Total GHG emissions on pilot farms ('on farm' + 'off farm') expressed per ha (blue bar using left Y-axis) and expressed per ton milk (red dashes using right Y-axis) per regions (2010 data).*

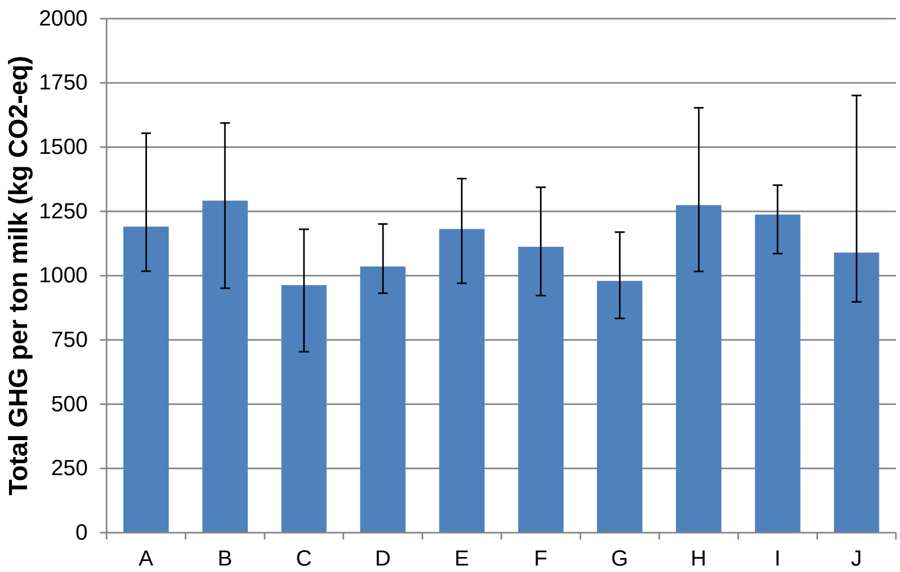

Figure 19. *Total GHG emissions on pilot farms ('on farm' + 'off farm') expressed per ha with minimum and maximum values per region (2010 data).*

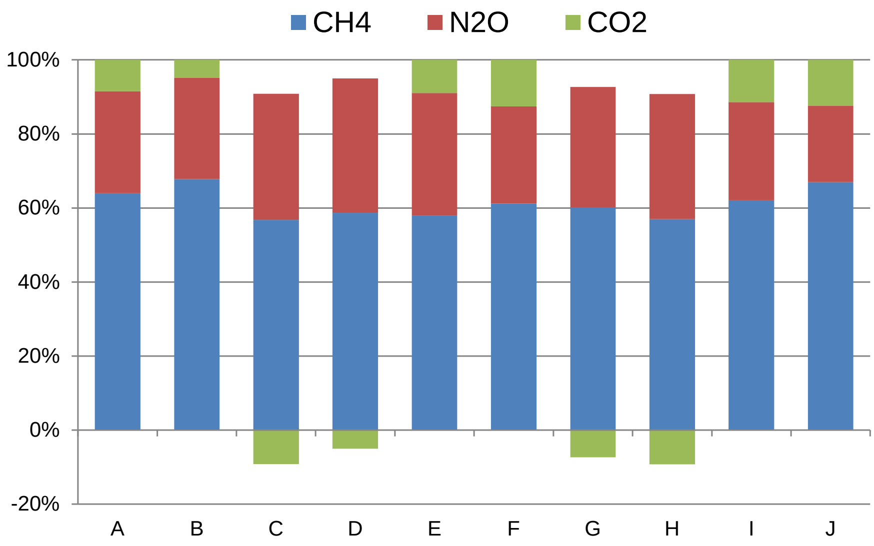

Figure 20. Relative importance of different sources of GHG emissions on pilot farms per region.

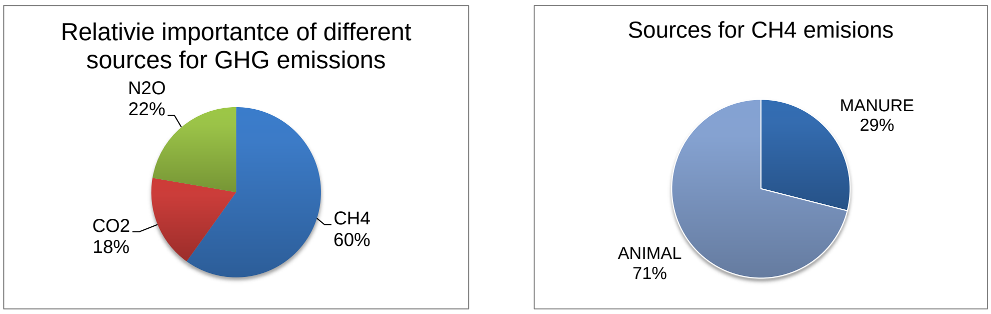

Figure 21. Example of results for one farm or one region

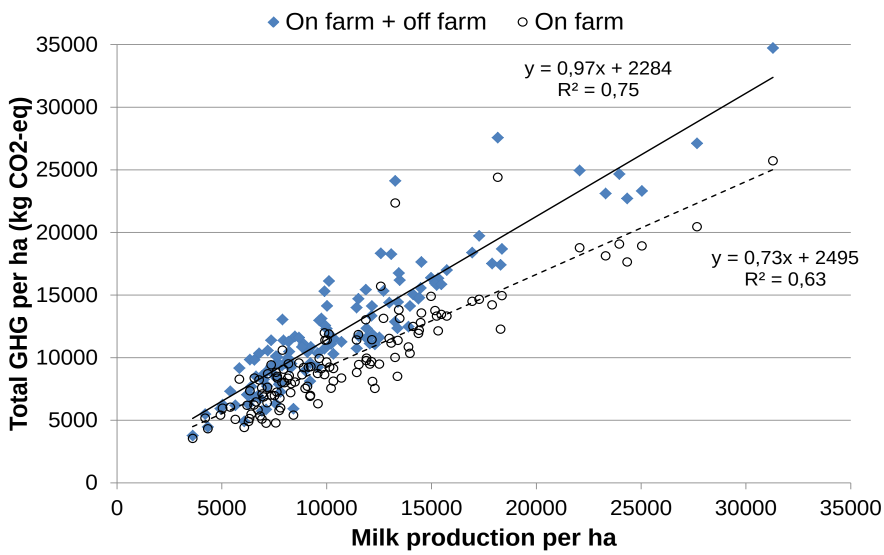

Figure 22. Relationship between milk production per ha and total GHG emission per ha on pilot farms in regions in North Western Europe. Solid line represents the relationship of on+off farm; dashed line the relation of only on farm.

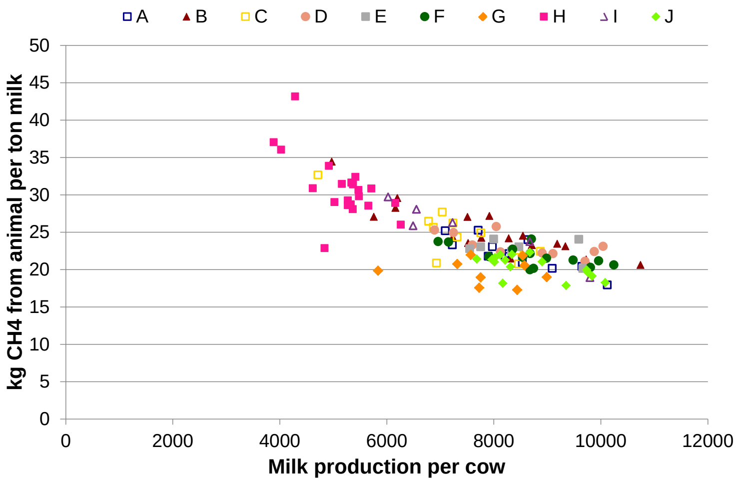

Figure 23. Relationship between milk production per cow and the CH_4 emissions from animals per ton milk on pilot farms in regions in North Western Europe.

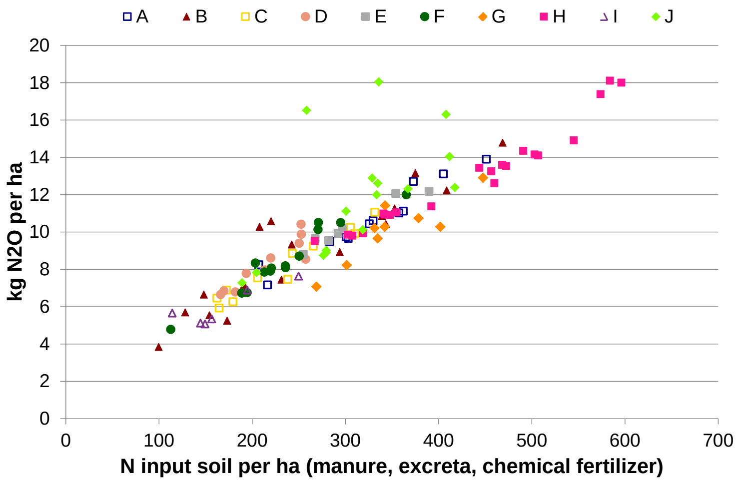

Figure 24. Relationship between N input to the soil per ha and total N_2O emissions per ha on pilot farms in regions in North Western Europe.

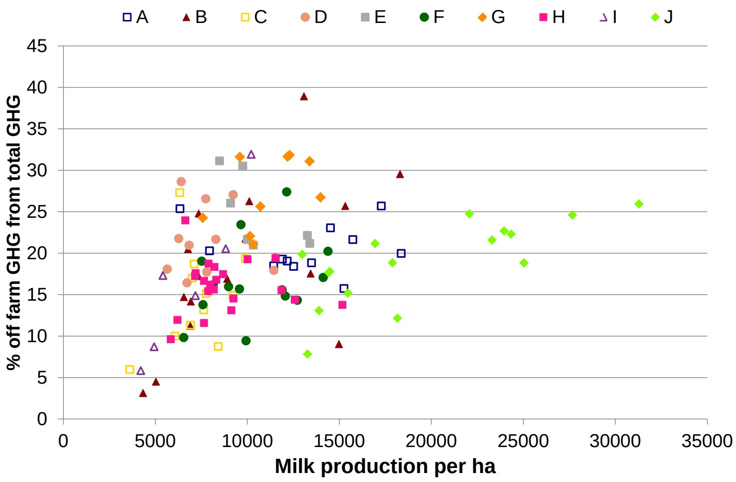

Figure 25. Relationship between milk production per ha and the percentage of 'off farm' GHG emissions on pilot farms in regions in North Western Europe.

2.6 **Biodiversity potential** (E. Lorinquer[8], S. Foray[9])

We have chosen to work on biodiversity potential in DAIRYMAN because agriculture is linked to its environment and therefore plays a strong role in biodiversity. Biodiversity is a major global public and collective good: a source of life, a support for human activities, a factor in development and wealth; there is real need to know more about how livestock farming influences biodiversity.

Biodiversity plays a major role in sustainability both at farm and regional scale.

The question for DAIRYMAN was: **How can biodiversity be evaluated in a rapid and simple way while taking into account farm practices?**

To answer that question a French tool has been adapted and tested on 1 or 2 farms of each region.

This tool takes into account that biodiversity is closely linked to agricultural practices such as soil management and crop rotations, the exploitation of permanent grassland, the methods used against pests, etc.

The length of a crop rotation, e.g., favours natural enemies and reduces the risks of pests. Effects are amplified when several species are associated with the crop rotation. Introduction of temporary grassland into the crop rotation is beneficial for the soil fauna and especially for earthworms.

The expression of biodiversity may also vary significantly depending on the mode of permanent grassland management. The expected biodiversity based on the level of fertilization and the exploitation mode of the grassland (intensity of defoliation) can be represented by the following graph.

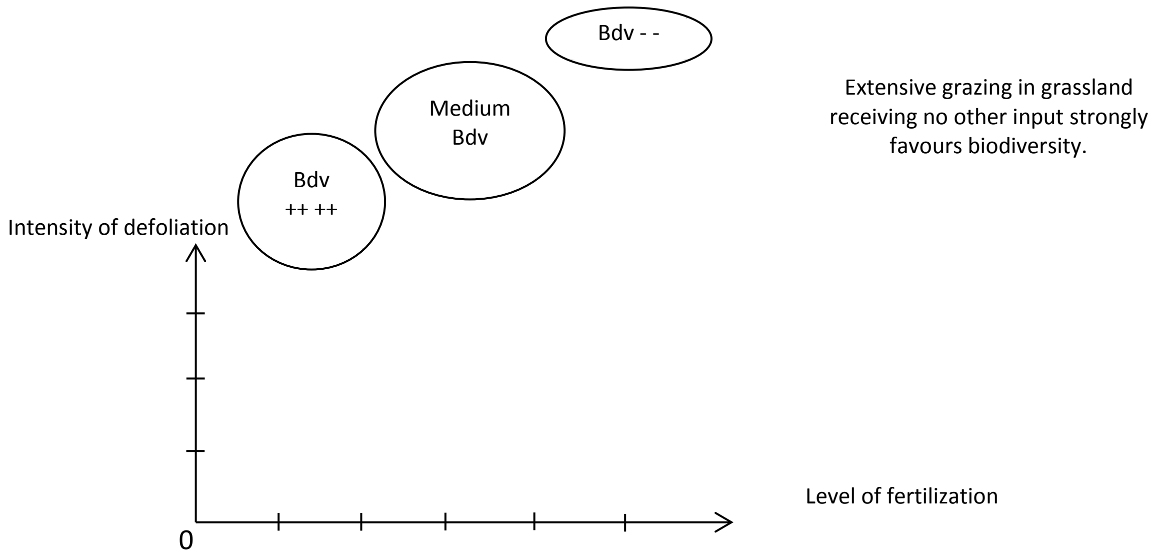

Figure 26. Graphic representation of permanent grassland biodiversity as function of their management mode (source: Idele, Aline Chanséaume).

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Finally, the use of different pesticides often has a negative effect on the soil fauna even if this fauna is not the target of the practice. These effects can either be direct or indirect.

The tool is also based on the hypothesis that different flora and fauna species need habitats: the more habitats (size, types) the more species can be accommodated.

The tool is an Excel file: the first spread sheet focuses mainly on farm practices and the second on the different types of AES (Agro Ecological Structure) present on the farm. The types of AES are defined and presented in a Word document.

Different types of AES (nature, shape…) are categorized but this requires expression in the same unit: surface of the elements.
All AES can be divided into two categories:
- ✓ Structures that could be attributed to a plain area like grassland.
- ✓ Structures that could be attributed to a volume like trees.

Volume shapes are considered as basic shapes: e.g. cobblestone or cylinder.

2.6.1 Data required and protocol

The data required to assess biodiversity potential are derived from the practices of the farmer and description of the landscape of the farm. As mentioned above, this tool does not assess the actual biodiversity but the potential biodiversity linked to the number and diversity of habitats for different species and, of course, also to the management of these shelters.

A range of steps must be taken and each step requires different data:
- For the first step, the different fields of the farm will be identified on an "orthophotoplan" or "map" (e.g. CAP – see Figure 27)

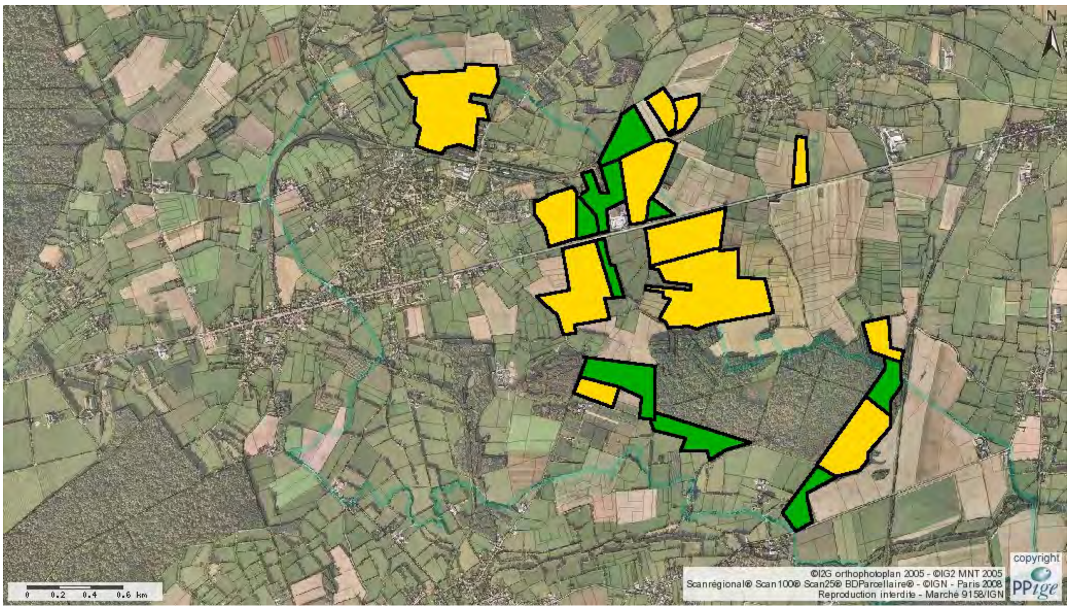

Figure 27. Example of a map/photograph illustrating the breakdown of the fields and uses of the farm analyzed in order to start biodiversity potential assessment.

- The second step is to estimate and identify most of the agro-ecological structures (AES) in each field from the "orthophotoplan", i.e. number of trees, length of hedges, forest ... (see example of AES in Table 14).
- The next step requires a farm visit in order to:
    - check the pre-identified agro-ecological structures (trees, type of hedges…)
    - verify the existence of others structures
    - measure/count the structures not visible on the map

Table 14. Example of data included in the Excel sheet.

TYPE OF AGRO-ECOLOGICAL STRUCTURE	CHARACTERISTICS OF AES	UNIT
Isolated tree (number of trees)	*small < 8 m*	*Nb(number)*
	medium 12 m	*Nb*
	high> 16	*nb*
	crown cut trees (+/- 10 m)	*nb*
Hedges (m)	*low +/- 1m*	*m (metre)*
	bushy, spinney, shrubby /arbustive +/- 5.5 m	*m*
	arborescent +/- 10m	*m*
Wall (m)	*small (50 cm)*	*m*
	medium (1 m)	*m*
	high (1.5 m)	*m*
Border of wood/forest (or small wood) (m)	*12 m high*	*m*
Bordering park/paddock (4 wire fences / bramble fences) (m)	*Standard*	*m*

Each file has been copied into a database that contains all analyzed farms.

Table 15. Data required to characterize practices on the farm.

SCALE	DATA REQUIRED	LINK WITH BIODIVERSITY
Farm	Agricultural area (ha)	Characterize the farm
Crop rotation	Forage area (ha)	Characterize the farm; take account of soil tillage; diversified crop plan (rotation) leads to diversified practices and habitats
	Temporary grassland (< 5years - ha)	
	Permanent grassland (ha)	
	Maize (ha)	
	Other forage crops (ha)	
	Others crops (cereals…) (ha)	
Fields	Number of fields over 10 ha	Explain connectivity between different AES
	Average size of the 3 main fields (ha)	Characterize the farm
	% of AA with at least one insecticide	Use of pesticide, impact on aquatic species
	% of AA with at least one herbicide	
	Beginning of the cutting period of grassland	Impact on birds nesting, on pollination
AES	Maintenance/management of the area under fences	Have a better understanding of the practices of the farmer; more diverse species can shelter in more diverse AES
	Maintenance/management of wetland /marsh area	
Varieties	Number of crops on the farm	Crop diversity promotes diversity of auxiliaries and reduces the risk of epidemics or invasion by a pathogen.
	Number of crops in the main rotations	

2.6.2 Indicators calculated

Indicators are mostly calculated from the observation on the "orthophotoplan" to evaluate the quantity of AES on the farm. As mentioned before, in order to explain the biodiversity potential of the farm all AES are converted into one unit called "m² equivalent of biodiversity" or "m² equivalent of AES". This requires shapes to be converted into a plain area. The conversion factors are presented in Table 16.

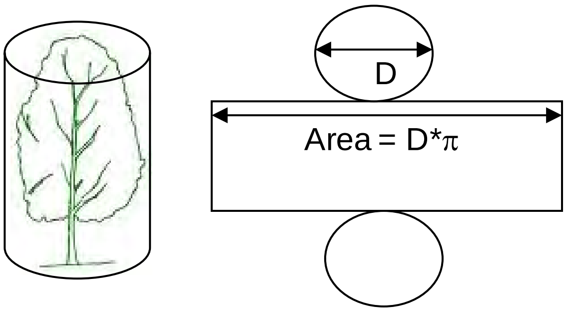

Table 16. Equivalence AES in m².

TYPE OF AGRO-ECOLOGICAL STRUCTURE	CHARACTERISTICS OF AES	EQUIVALENT OF AES AREA (M²)
Isolated tree (number of tree)	*small < 8 m*	145
	medium 12 m	456
	high> 16	931
	crown cut trees (+/- 10 m)	471
Hedges (m)	*low +/- 1m*	2 220
	bushy, spinney, shrubby /Arbustive +/- 5.5 m	3 210
	arborescent +/- 10m	13 101
Wall (m)	*small (50 cm)*	261
	medium (1 m)	362
	high (1.5 m)	462
Border of wood/forest (m)	*12 m high*	1 200
Border of paddock (4 wire fences/ bramble fences) (m)	*Standard*	100
Bank/talus / moat (m)		10 000
Fallow (ha)		10 000
Permanent grassland (ha)		10 000
Moors/farmhouses-heath/mountain pasture/ (ha)		10 000
Buffer strips (ha)		10 000
Pond /pool (ha)		10 000
Wetlands /marshlands (ha)		10 000
Peat (ha)		10 000
Terrace / asteland (ha)		10 000
Agroforestry (ha)	*"pastoral forestry" (average tree)*	55 600
	« agri-forestry » (average tree)	50 160
Riperian forest (m) (Riverine : forest + river)		5 680

2.6.3 Illustration of the results

The following graphs are illustrating the use of the indicators given above

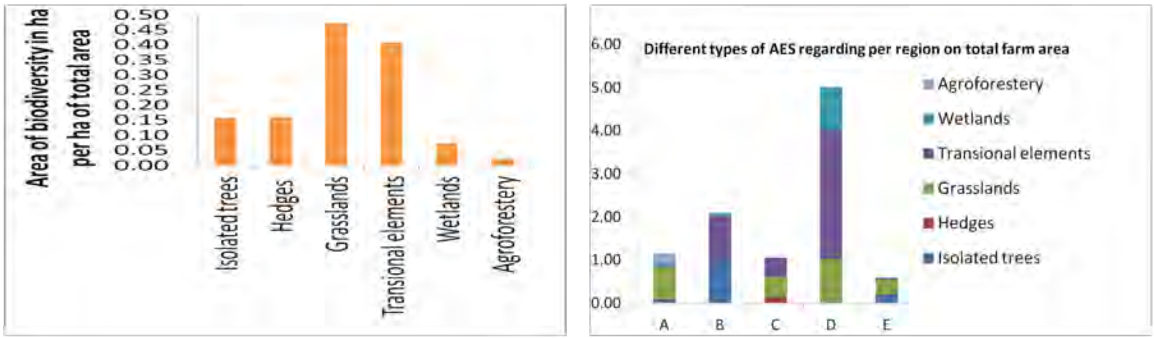

Figure 28. Illustration of AES and its different components, linked to the agricultural area of the characterized farms.

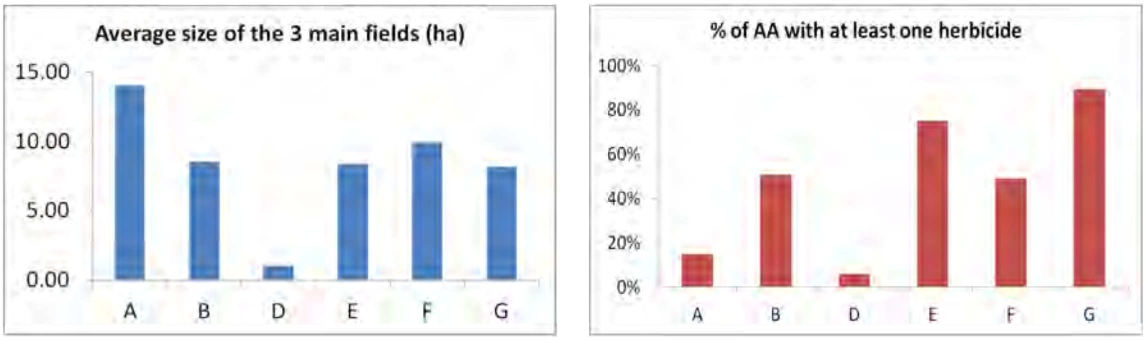

Figure 29. Indicators of practices linked to biodiversity, at farm level, on the farms.

The AES method gives a global view of the biodiversity potential at the farm scale. Comparison between farms or between different regions can be difficult because of different contexts, landscape etc. Recommendations for improvement have to be farm- or region-specific to take account of local conditions and requirements.

2.7 Dairyman Sustainability Index assessment

(K. Herrmann[10] and M. Elsaesser[11])

According to the definition of the Brundtland Commission sustainability includes economic, ecological and social aspects. This means that sustainable dairy farms should be environmentally compatible, economically viable, and socially responsible. But how can the sustainable development of an individual farm be assessed and analysed? And why is it useful?

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Our proposal is the development of a tool called "DAIRYMAN Sustainability Index" (***DSI***), not only for assessment and comparison of single parameters of farm management or farm situation but also for factor combinations to enable a holistic assessment of the DAIRYMAN pilot farms. Such a tool can also help to gain insight into the overall development of farms: strengths and weaknesses are shown and farmers can see how their management influences their results in the fields of economic, ecologic and social aspects; this enables them to continually improve their performance.

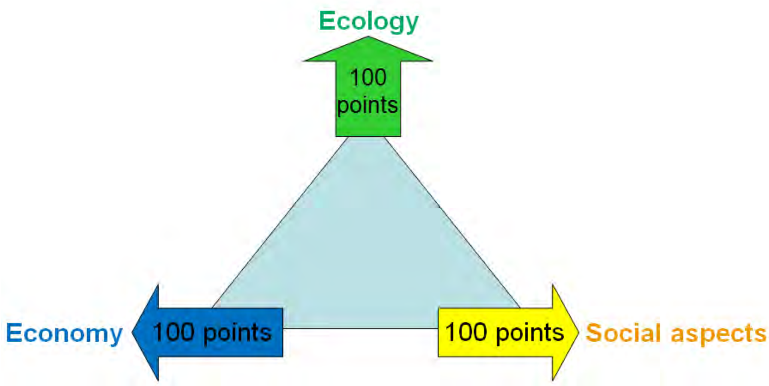
Our systems approach was developed as follows.

2.7.1 Step by step to the Dairyman Sustainability Index (DSI)

1. Agreement on weighting of ecological, economic and social aspects
2. Choice of single sustainability factors
3. Weighting of factors
4. Determination of target fulfilment
5. Calculation of results for economy, ecology and social aspects
6. Presentation of the total DSI score

Agreement on weighting of ecology, economy and social aspects

Based on the "three-pillar model" it was decided that ecologic, economic and social aspects would be treated equally, so that in each pillar a maximum of 100 points could be reached.



Choice of indicators

The basis of an overall sustainability evaluation is the application of a system of indicators. It was decided that as it was not possible to collect all data needed to measure "true" sustainability for the ***DSI***; the indicators should already have been collected within the DAIRYMAN pilot farm network so that the data required would be available for all partners (see 2.1 – 2.5). An exception is made for some social indicators for which further information can be gathered with a short, simple and uniform questionnaire that might supply missing data for a description of farm sustainability. Biodiversity or soil erosion susceptibility are important attributes which could not yet be taken into account. This means that the system is not complete at the moment and will be further developed stepwise.

A DAIRYMAN working group defined the following set of indicators:

Economy	Ecology	Social aspects
1. Income per kg milk	1. N balance per ha and per kg milk	1. Education
2. Income per family working unit	2. N efficiency	2. Working conditions
3. Farm income	3. P balance per ha and per kg milk	3. Farm continuity
4. Dependency on subsidies	4. P efficiency	4. Social role and image
5. Exposure to price fluctuations	5. Agri-environmental payments	
	6. Greenhouse gas emissions	

The economic data and nutrient balances of the DAIRYMAN pilot farms are determined at dairy and at farm level because many farms of the DAIRYMAN pilot farm network have several other enterprises besides dairy farming. We chose parameters at dairy and at farm level to be able to take into account all kinds of farm structures.

Economy (see 2.2):

1. Income at **dairy level**

   (€ per 100 kg FPCM): $\frac{(Revenues - Annual\ Expenses - Depreciation - Interest\ )_{dairy}}{\frac{Milk\ production\ (kg\ FPCM)}{100}}$

2. Family labour income at **dairy level**:

$$\frac{(Revenues\ - Annual\ Expenses\ - Depreciation\ - Interest\ )_{dairy}}{(Family\ Labour\ Units)_{dairy}}$$

3. Farm income

   (per family labour unit): $\frac{Revenues - Annual\ Expenses - Depreciation - Interests}{Family\ Labour\ Units}$

4. Dependency on subsidies:

$$\frac{Public\ payments}{Revenues - Annual\ Expenses - Depreciation - Interests}$$

5. Exposure to price fluctuations at **dairy level**:

$$\frac{(Variable\ Costs + Depreciation + Interest - Paid\ Labour\ )_{dairy}}{(Revenues - Public\ Payments)_{dairy}}$$

Ecology (see 2.3 and 2.4):

1. N balance per ha: N input minus N output at farm level
2. N balance per kg milk: N input minus N output at farm level
3. N efficiency: N output per N input at farm level
4. P balance per ha: P input minus P output at farm level
5. P balance per kg milk: P input minus P output at farm level
6. P efficiency: P output per P input at farm level
7. Payments for environmental activities: agri-environmental payments per ha e.g. for cultivation of nature protection land, no use of pesticides, etc. (assessed in the economics)
8. Greenhouse gas emissions: GHG emissions at dairy level in 1000 kg CO_2-eq per ton milk

Social aspects

Most of the social indicators are included in a questionnaire which is given to every family worker. Answers of the questionnaire are scored and then integrated into the DSI validation. Some information concerning basic education, holidays, work load, employment is already available in the descriptive data (see 2.1).

1. Education
   1.1 Basic education
   1.2 Training courses
2. Working conditions
   2.1 Personal satisfaction (Work-Life-Balance? How often do you feel stressed? Are you happy with your salary? Activities outside the farm?)
   2.2 Work load per family labour unit
   2.3 Holidays
   2.4 Free time
3. Farm continuity
   3.1 Preparation of farm succession
   3.2 Is there a possible successor?
4. Social role and image
   4.1 Relation to neighbourhood, reputation within the area, organization of public events on the farm, etc.

Weighting of indicators

An important point about the ***DSI*** system is that not all selected factors are of equal significance, e.g., N efficiency may be less important than N balance. This means that each single factor needs to be judged and evaluated within the 100 point scale. This factor weighting is difficult because the decision may be subjective – one region or even a farm may consider that holidays are really important whereas another region may focus more on animal welfare and would give that indicator a higher score. The goals of the regions have an influence as well. Ireland and Brittany, e. g. consider phosphorus important, so they would emphasize the indicators dealing with P.

In the Netherlands on the other hand nitrogen pressure plays an important role which means that their valuation would differ from the other two regions. Even if the task of the DSI was to harmonize the values between all partners in the DAIRYMAN project, this objective could not be realized until now in view of the varying views of the DAIRYMAN partners. Moreover the “one and only truth or reality of sustainability” is not the focus of the index, but the DSI is well suited to monitor the impact of management plans on sustainability evolution on a given farm or a group of farms in a defined region. In order to minimize bias exerted by specific single influences we asked several experts from different regions.

Definition of target fulfilment

As described in Chapter 2, special DAIRYMAN data collection files were developed to compare farm performances of all participating regions. This is necessary because every region has its own methods to calculate, e.g., economic results or nutrient balances which cannot be used for comparison. So we could not use already existing target values available from benchmarking or other existing databases in the partner regions; this meant that we had to choose special target values within our farm network results.

It was decided to calculate quantile 10 and quantile 90 out of the dataset of our 127 pilot farms and to take these as reference values. In this way pilot farms that are within the best 10% are awarded full marks for the particular indicator and farms that are within the worst 10% receive no points for the respective indicator. Points between these quantiles are calculated by linear regression.

Calculation

The total scores for economy, ecology and social aspects are calculated by multiplying the validated values with the scores and the sum of these is the total value. The calculation for the economic aspect is presented in Table 17.

Table 17. Example of calculation for the economic part of the DAIRYMAN sustainability index.

Score	**Income per kg milk**	**Income per fLU**	**Farm income**	**Dependency on subsidies**	**Exposure to price fluctuations**
0	< 2.65 €/100 kg	< 13357 €/fLU	< 19184 €/fLU	> 135.29%	> 103.65%
0.5	13.22 €/100 kg	65462 €/fLU	66369 €/fLU	77.51%	78.13%
1	> 23.79 €/100 kg	> 117567 €/fLU	> 113553 €/fLU	< 19.73%	< 52.61%
Points	max. 16 points	max. 34 points	max. 22.5 points	max. 9.5 points	max. 18 points
Example	21.7 €/100 kg	114400 €/fLU	75800 €/fLU	142%	49%
Validation	0.9	0.97	0.6	0	1
Calculation	0.9*16=14.4	0.97*34=32.98	0,6*22.5=13.5	0*9.5=0	1*18=18
Result	14.4 points	32.98 points	13.5 points	0 points	18 points
Result economy: 78.88 points out of 100 possible points					

Presentation of the total DSI score

Results for ecological and social aspects are calculated in the same way as shown above for the economic aspect; this means that the DSI can be presented in different ways. The "total sustainability score" is calculated (Fig 30) by summing the results of the three pillars. This value is only valid to gain a first impression of rankings. But this then urgently needs a detailed study of the results (Figure 31) because a farm cannot be sustainable if it achieves 200 points in total, while most of the points arise from social and economic aspects. This means that a minimum limit needs to be set for every pillar; this limit should be one third of the total possible points as minimum and two thirds as an approximation of a target fulfilment for a sustainable farm.

Total DSI scores of farms can be used (Figure 32) to monitor its evolution and/or allow comparison with others farms of the same farm type and region (Figure 33) to identify its strengths and weaknesses.

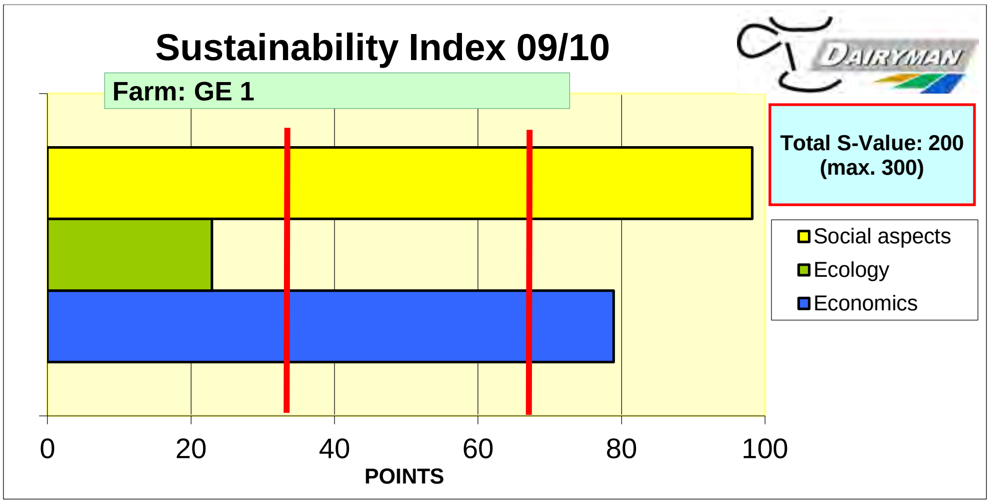


Figure 30. Results from one single farm at one specific moment.

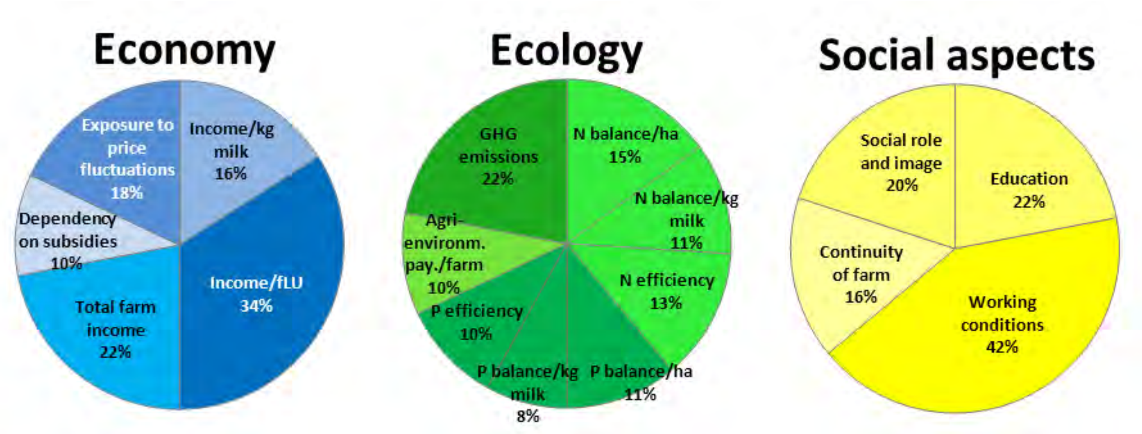


Figure 31. Validation of indicators within the three dimensions of sustainability: economic, ecological and social aspects.

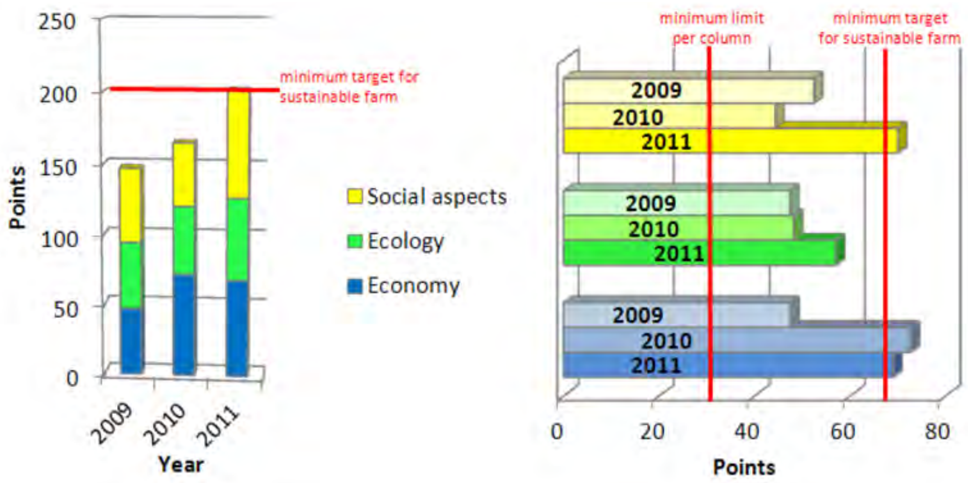


Figure 32. DSI of a single farm over time in order to judge development of that farm from 2009 – 2011.

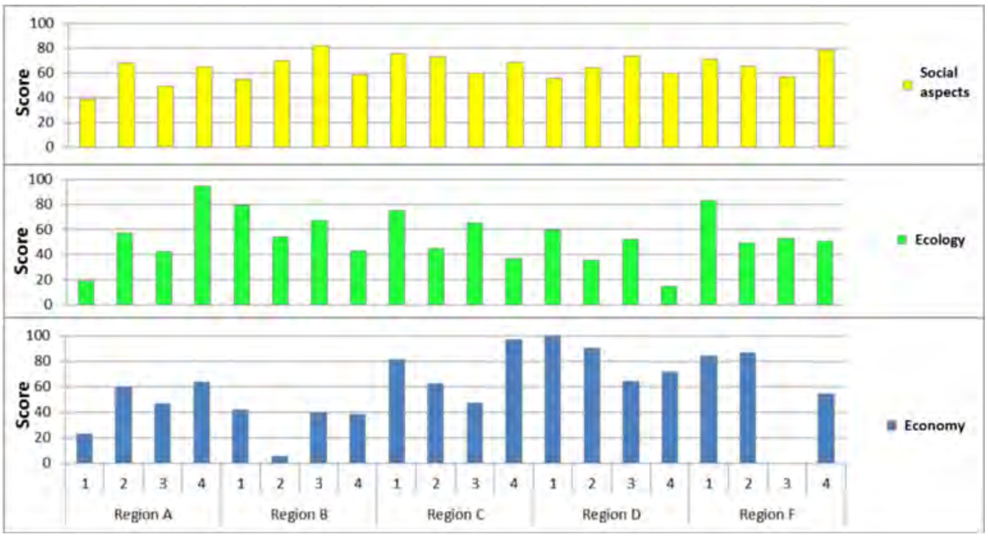


Figure 33. Total DSI scores of 20 farms from different regions.

2.8 Difficulties and perspectives to improve data collection

Table 7 summarizes the encountered difficulties and suggested improvements to avoid errors and over- or underestimation of the required data. A frequent (and probably the main) problem in developing data collection is assuming that everyone involved shares the same understanding of the data definition. Indeed, different stakeholders may interpret some words differently. To avoid such misunderstandings requested data should be provided with a clear definition and some examples. Where possible, a drop-down list of options should be considered.

Table 18. Difficulties and ways of improvement for various types of data.

	DIFFICULTIES MET AND SOLUTIONS PROVIDED	POTENTIAL IMPROVEMENTS
Descriptive data	The greatest difficulty is to find a compromise between required information and its availability. While some information may be very relevant to advisors and researchers it may be difficult for the farmers to provide it. Therefore, to avoid under- or over-estimation, data should be treated with caution and the limited accuracy of some data for the databases must be taken into account. Consideration should be given, when possible, to deriving data from other sources Indeed, by doing so, the farmer survey will be “less time consuming” and less data will need to be encoded in the files; hence sources of error will be reduced.	Farm strategy: it would have been interesting to have acquired more information on contracts for milk sales (short chain, transformation, kind of milk delivery, …) Animal performance: it would have been interesting to gather more information on milk quality (cell counts, diseases, …) Concentrates: exact definition of concentrates, by-products and home-grown concentrate composition and the group of animals using these.
Economic data	Collection of data for economic analysis is a compromise between simplicity and precision. This is especially true for the estimation of the workload, but also for calculated costs (opportunity and depreciation costs) and the allocation procedure. It is impossible to divide the economic flows of mixed farms perfectly between all components (milk, meat, crop, ..). Farms are mixed as the combination of enterprises may have a positive effect on the total farming system. In these systems, some internal flows of goods, such as straw and slurry, are not quantified economically, but play an important role in the management of the farm. Total farm systems should be compared through variable expressed per area and per labour unit. As stock variations are not taken into account, averages from data collected over a few years should be presented.	The economic model could be improved by exactly defining the calculated costs such as depreciation and opportunity costs. To improve accuracy, stock variations (changes) within one year for all agricultural goods should be considered. To ensure consistency and common understanding of definitions among data collectors, they have to be trained before gathering the complete dataset.
Mineral data	The main difficulty was to agree on a common methodology. Each institute calculates the mineral balance in its own way, with some difference in the	A problem arises, particularly on mixed farms, where nutrients are allocated overdifferent enterprises on the farm (crops, milk …) and where

	DIFFICULTIES MET AND SOLUTIONS PROVIDED	POTENTIAL IMPROVEMENTS
	data needed, the mineral content, or the way to calculate indicators. Data acquisition is not too difficult with the accounts of the farm (amount of mineral fertilizer with content, weight of sold animals ...). But stock variation is more difficult to estimate. Indeed, silage or organic fertilizer stocks are not easy to calculate and these estimations are often done by the farmer without any training. Stock variation can be considered zero when considering more than 3 years of analyses.	internal fluxes exist. This particularly applies for manure. Cows produce manure which is applied to the crops. In this case manure is an output of milk production and an input to the crop system. However, at farm level this is an internal flux which means that it is not taken into account.
GHG data	As with economic data, collection of GHG data is a compromise between minimizing the amount of data to be collected and the accuracy/sensitivity of the approach. Calculation of GHG emissions requires data that are not always directly available to farmers, advisors and/or researchers, e.g. data on C stock change in the soil and data on the composition of imported concentrates (cereals, rape, soya, etc.); this means that a 'best guess' estimate based on literature or expert judgment has to be made. Input data should therefore be taken with caution. Data collectors have to be trained before gathering the complete dataset: this ensures that interpretation of data definitions is standardized and differences in data between farms are not affected by variation in data collectors applying different criteria/perceptions.	Inputs for the calculation of GHG emissions need clearer definition. The current tool is based on a Tier 2 methodology. To investigate the improvements in GHG emissions (farm development), the results should be more farm- and/or region-specific. We therefore need a Tier 3 methodology where farm management and local circumstances are taken into account. The GHG emission evaluation of dairy production, including carbon storage in the soil, is a big issue for the dairy sector as permanent and long-term grassland has a strong capacity to stock carbon. Further research is needed to improve the evaluation of carbon storage under the different types of grassland and practices but this has to be integrated to be able to evaluate net GHG emission (gross emission minus C storage in the soil).
Biodiversity	The main difficulty was to appraise the time needed to assess biodiversity. It took from 0.5 day per farm up to 6 days, depending on the way in which data were collected. A guideline to define the information collection method would have been useful. The definition of the requested data should be clarified like the different types of agro-ecological structures (ex: permanent grassland). A first draft of instructions to use the biodiversity tool on a farm was proposed for the regions interested in assessing all pilot farms.	Assessing biodiversity potential is useful to compare a pilot farm with other farms in the same region. The tool used in the DAIRYMAN project is far from optimal but it allowed pointing out some ways of improvement and the need to go beyond farm level. The assessment should be done at a European scale. There is a clear need to show society that farmers are contributing to maintain AES and to maintain biodiversity.
Sustainability index	Validation and scoring of the parameters may be a problem, because this should be done in a common way for all participating regions in order	There are several indicators that should be included in such an overall evaluation to assess all important aspects of sustainability but in the

	DIFFICULTIES MET AND SOLUTIONS PROVIDED	POTENTIAL IMPROVEMENTS
	to demonstrate farm evolutions or comparisons between similar farms. A major difficulty is that regions have different priorities according to their cultural characteristics, regional problems and objectives. We tried to solve this problem by discussing this issue with a group of participants from all DAIRYMAN regions and common agreements, which of course might not be the "truth" in type of sustainability, but the commonly determined values can be taken as a DAIRYMAN group version which might be improved continually.	framework of DAIRYMAN we could not collect all necessary data to evaluate these. To improve the DSI we wish to integrate the following indicators: • Nutrient status of the soil (P and K) • Pesticide use • Energy use efficiency • Biodiversity • Animal welfare Another point is the choice of reference values: until now we only took the target values of reference year 2010, which can be problematic, especially when looking at the economic results, e.g. their dependence on the price of milk. The social indictors to evaluate the social situation of the farm are still limited. Further research is required to improve the indicators to be used at this level.

3. Farmers' objectives (E. Castellan)[12]

The portrait of the farm helps to underline different assets and constraints specific to the farm and helps define actions within these constraints. In addition to the discussion about farmer practices, several questions can be asked to help identify the farmer's objectives. While in discussion with the farmer(s) it is essential to keep in mind that all elements of sustainability have to be taken into account: i.e. economic, environmental and social objectives. Indeed, these three pillars of sustainability can sometimes have antagonistic effects although all of them have to be considered for sustainable development of the farm. Especially, environmental aspects will be easily considered by farmers if they are able to provide themselves profitable incomes while respecting social wishes.

Care is required if there are several farmers on the farm, as the discussion has to take place with all and all of them have to give their opinion. A list of questions that may help the discussion is given below. It is important to go through all of the farming system without emphasizing some problems/elements while ignoring other elements that may be relevant.

Within the current context, what are the main concerns that influence your choice?

- Maintain or improve working conditions
- Produce more
- Increase milk production per cow
- Improve genetic potential of the cattle
- Control costs
- Increase the value of farm products
- Preserve farm autonomy (feed, fertilization, energy, pesticides…)
- Reduce waste and its environmental impact
- Comfort an installation (for example with high technology, equipment to clean easily) of a young farmer or recent investment
- Prepare farm succession
- Increase production per hectare (intensification)
- Other……………………………………………………………

Concerning the balance between the different enterprises of your farm, what is your global strategy?

- How do you see your farm in 5 years?

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Elements of prospect	+	-	=	Expected Value
Quota or delivered milk (1000l)				
Number of cows				
Production / cow				
Agricultural area				
Grassland (ha)				
Maize (ha)				
Sold crop (ha)				
Labour				

- Supposing that you want to produce more milk, what could be the main factors limiting this increase? (rank 3 factors)

Limiting elements	Rank
Buildings or milking parlour	
Regulations (size)	
Competition with other branch of the farm	
Labour availability	
Forage area required to feed the cattle	
Area required for the manure spreading	
Loan capacity	
Others : …………………………………..	

How do you feel about current environmental pressures?

- Environmental regulations
  a. Are you in an environmentally sensitive area (vulnerable area, water catchment area, Natura 2000,…)?
  b. Involved area (%AA)?
  c. What are the consequences for your farm management and development?

- Rank the following environmental issues according to your priorities?

Environmental issues	Rank
Water quality (nitrate, phosphorous)	
Water consumption	
Pesticides	
Biodiversity	
Greenhouse gases	
Energy consumption	

- What would you do on your farm to reduce the impact on water quality or air pollution or soil erosion or … ?
  a. Decrease fertilization
  b. Change rotation
  c. Increase grassland
  d. Other : …………….

- How do you consider your input use (pesticides, mineral energy,…)?
  a. Low
  b. Average
  c. High

- What solutions will you be prepared to apply to reduce input uses (pesticides, minerals, energy,…)?
  a. Decrease amount
  b. Adapt your equipment (spraying machine adjustment, nozzle choice, milking parlour or the milk tank, photovoltaic panels, biogas production)
  c. Change your rotation
  d. Variety choices
  e. Other:…………………………..

  Are you already applying some of these practices?
  What could be the obstacle to their implementation?

- Are you concerned about the greenhouse gas issue?

- What are your social concerns?
  a. Work load
  b. Free time during the working week
  c. Free time for holiday
  d. Free time for professional involvement
  e. Management (quality of relationship between family workers, labour,...)
  f. Other:…………….

- In conclusion, defining the farmer's objectives results in a combination of regional objectives, results of the farm (collected data), identifying assets/strengths and constraints, complementary discussion with the farmer (specific interest). Once objectives are defined, specific actions can be chosen to link farmer's practice, farm assets and constraints, and regional context.

4. Farmers' actions (A. Grignard)[13]

To reach his objectives, the farmer has to choose a strategy. This strategy has to lead to several actions. While writing the farm development plan, in close cooperation with the farmer, the advisor will pay special attention to the relationship between actions and objectives. Indeed, no objective should be left without an action. Furthermore, each action should be accompanied by at least one indicator. This indicator is a measurable parameter that will allow evaluation of the performance and efficiency of the action to reach the target. The target is the indicator(s) value(s) we want to reach to consider the objective as fulfilled. At the beginning of the strategy implementation, baselines will be defined as well. Baselines are indicator values before starting the action. The ratio between the target and the baseline will illustrate how efficient the action is.

According to the efficiency of the actions, the strategy will have to be maintained or improved. Implementing a farm development plan is challenging in itself as it aims to continually improve the performance of the system in a structured way.

A precise calendar must be constructed to help the farmer to plan his activities.

Table 19. Example of actions, indicators, baseline and target that may be used to reach a concrete objective.

Objective	Reduce risk of nitrogen leaching
Actions	Quantification of available N before sowing in order to adjust fertilization plan
	Definition of the quantity and quality of the manure spread in order to take these into account in the fertilization plan
Indicators	Value of Nitrogen Potentially Leachable (NPL) before sowing and, so, reduction of N fertilization allowed
	Reduction of mineral N fertilization allowed based on proper consideration of manure potential (quantity*quality*efficiency)
Baseline	Initial value of N fertilization used for the different crops
	Initial value of mineral N fertilization used for the different areas
Target	Value of N fertilization needed by the different crops while taking into account the available N before sowing
	Initial value of mineral N fertilization needed by the different areas when taking into account a good valorization of all produced manure

4.1 Analyzing farmers' action choices

This part of the manual presents a way to analyze the improvement plan (actions, measures) chosen by farmers according to their expected impact on farm performances.

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4.1.1 Action classification and balance

The first step of the analysis consists of classifying the actions according to their direct impact on the different farm management elements, i.e., categories. Six main categories have been identified: (A) feed management, (B) herd management, (C) grassland management, (D) crop management, (E) fertilization management, (F) environment management (Table 20).

Table 20. Actions to optimize the management of different farming elements.

Topics	Subtopics	Codes
Feed management	*Feeding in general*	A1
	Forage	A2
	Concentrate	A3
Herd management	*Young cattle*	B1
	Dairy cows	B2
	Reproduction	B3
	Health	B4
Grassland management	*Quality (diversity)*	C1
	Productivity	C2
	Calendar	C3
	Area used	C4
Crop management	*Species*	D1
	Techniques	D2
	Productivity	D3
Fertilization management	*Fertilization plan*	E1
	Mineral fertilizer use	E2
	Organic fertilizer use	E3
Environment management	*Biodiversity*	F1
	Water	F2
	Greenhouse gases	F3
	N & P leaching and volatilization	F4
	Reduction consumption of energy	F5
	Increase production of energy	F6

Furthermore, the actions are balanced according to their ability to improve environmental sustainability of the farm together with their main impact on the technical performances of the farm. This level of indirect impact is translated into “environmental function of the action”. This is defined as the capacity of the action to improve the environmental performance of the farming systems. The use of the concept of environmental function results from the wish to illustrate the diversity of strategies used by farmers to improve their environmental performance while also improving their technical performance.

Indeed, some actions such as planting hedges or late cutting of grassland are considered as fully dedicated to environmental management (weight 1). Other actions, such as the reduction of nitrogen fertilizer and feed inputs or increase animal performance, also have an impact on the environment (reduction of nitrogen leaching, emissions of greenhouse gases, etc.) even if their primary purpose is economic. Therefore, based on a literature search and expert opinions, we balance all actions included in the Farm Development Plan based on their indirect impact on the environmental performance of the system (weighting of 0.25, 0.5 and 1) (Figure 34).

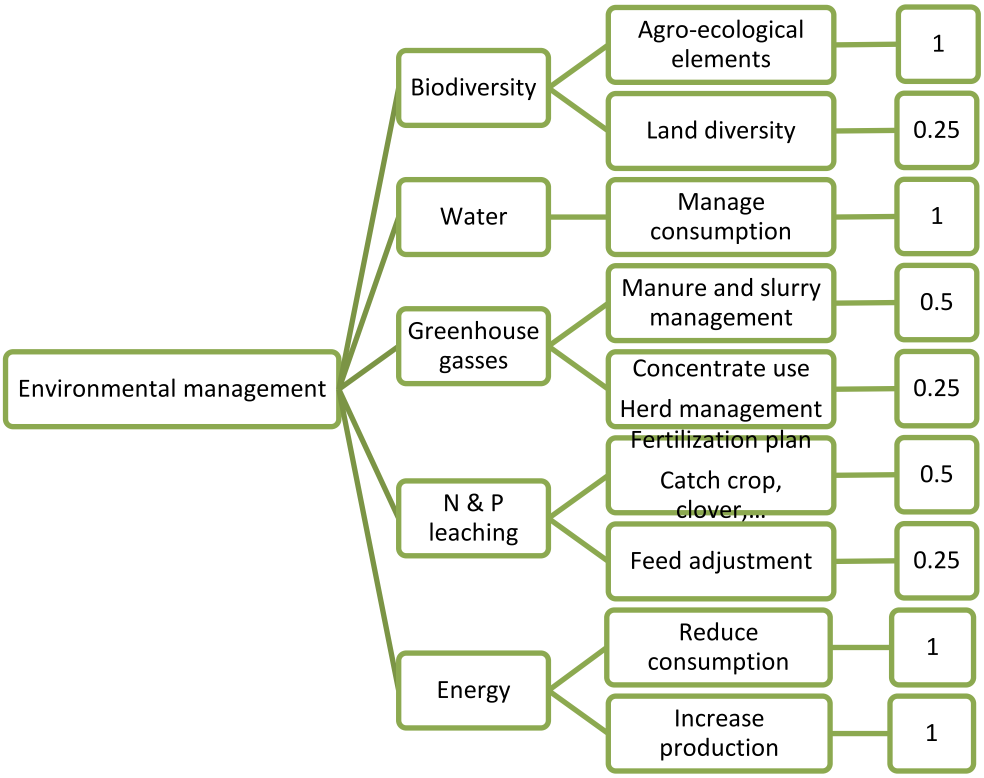

Figure 34. Weight allocated to the different actions according to their impact on farm management.

This approach based on the environmental function of the actions (for farmers, consumers and stakeholders) illustrates that it is possible to reach environmental goals while optimizing the different elements of the farming systems.

Actions directly linked with economic and social improvement also have to be taken into account. Table 21 presents an example of classification that could have been performed. Of course, an in-depth analysis of the improvement plans and strategies chosen by the farmers requires the definition of a balance that would assess the social and economic impact of actions.

Table 21. Example of classification for actions aiming to improve the economic and social performance of farming systems.

	Topics	Subtopics	Codes
Wishes to increase farm capital	Capital management	*Construction/Renovation*	H1
		Equipment	H2
		Revenue	H3
Wishes to improve the quality of life	Social management	*Reduce workload*	I1
		Contract out	I2
		Transfer/recovery	I3

4.1.2 Breakdown of actions – example of analyses

The main purpose of the methods to analyze farm development plans is to identify the actions to which farmers are receptive to guide agricultural institutes in their choice of research themes. Furthermore, the action value allows us to compare farmers' choices between farmers both at the intra-regional and inter-regional level. For example, Figure 35 shows wide variation in the choice of actions between regions. This variation can be attributed to a combination of factors such as the tools available to farmers to manage their enterprise, the regulatory rules implemented, funding provided by the state, the level of performance already achieved by farmers, their sensitivity to some subjects, advisory service sensitivity, importance of the theme according to the type of system related to the region, etc.

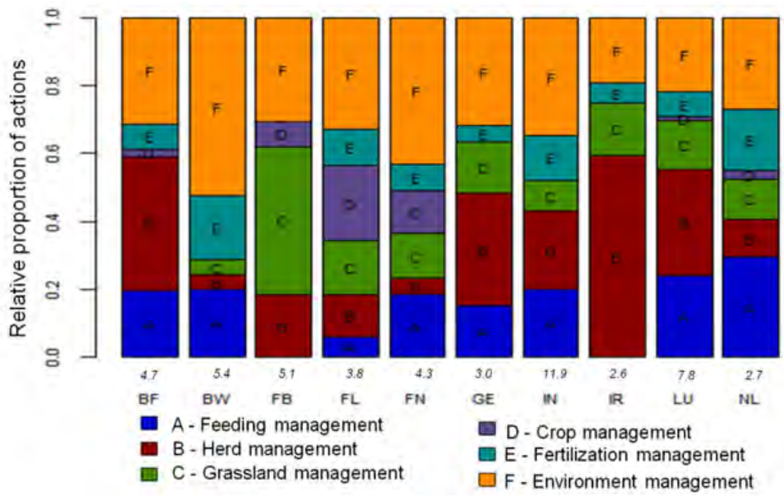

Figure 35. Breakdown of actions adopted by the pilot farms of the DAIRYMAN network, per region, according to their effect on farming system management. The average number of actions per farmer per region is indicated at the bottom of each column.

Taking into account the actions relating to the environment (Figure 36), clear differences were identified between regions. Some regions focus their actions on improving herd and animal performance and input consumption (e.g. Ireland, Luxembourg, the Netherlands) while others (e.g. Belgium and France) highlight actions that are more directly linked to the environment (biodiversity, reduced energy consumption, increased production, etc.).

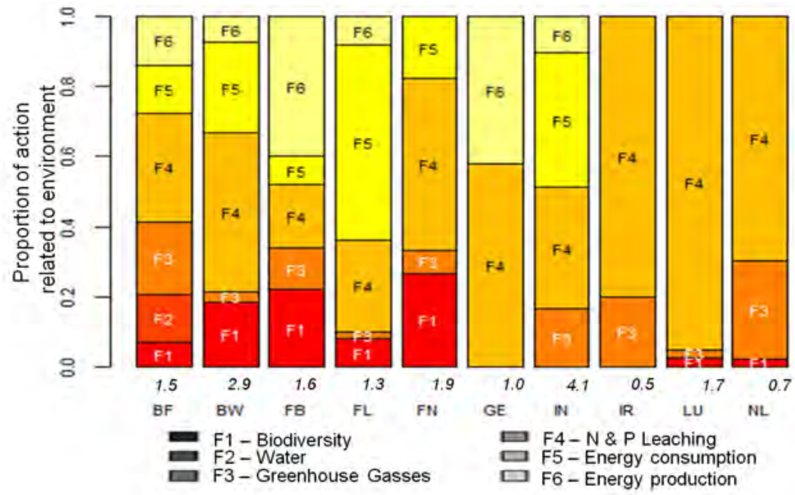

Figure 36. Breakdown of actions according to their effect on environmental management, per region. The average number of actions per farmer per region is given at the bottom of each column.

It follows from these observations that the same goal - in this case the improvement of environmental performance - can be achieved by combinations of different actions. This results in many questions arising, such as: why did some regions not implement actions related to energy production (solar or photovoltaic panels, biogas, etc.)? Is it due to a lack of financial support and therefore too long return on investment (Ireland) or is it because the action has already been taken before establishment of the project DAIRYMAN (Luxembourg)? In answering these questions, we can identify the needs of farmers, understand the importance of the geo-political context for the choice of actions by farmers and provide guidance on research themes. We can also identify the management tools to be developed in order to meet farmers' expectations.

Deeper investigation of each topic enables more precise identification of the farm management elements that are considered as major issues for farmers (Figure 37).

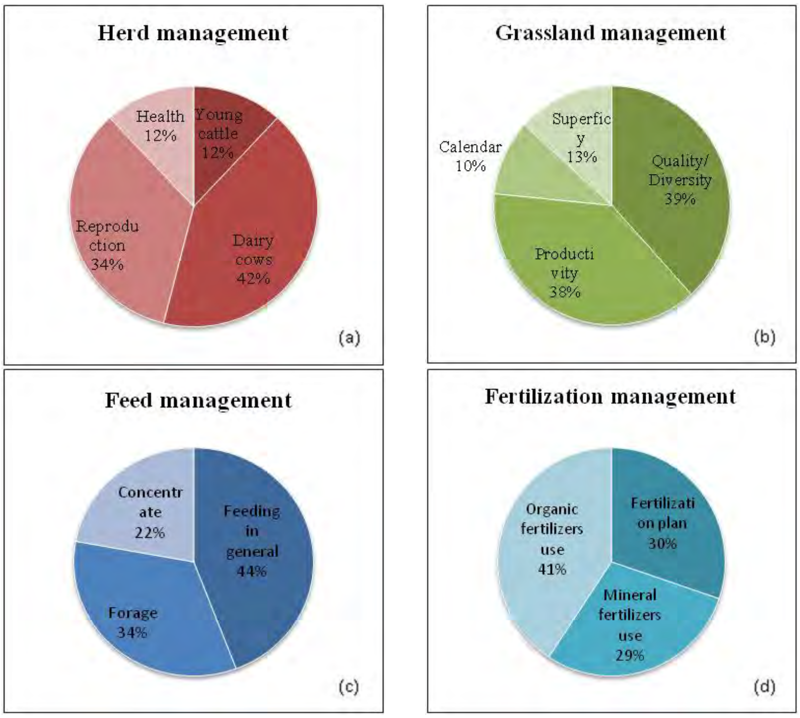

Figure 37. Example of breakdown of the actions at the sub-topic level for the four farm management elements taken into account.

Comparison (Figure 38) of these results with the information provided by the Knowledge Transfer Centre (KTC) involved in the project allows us to identify some discrepancies, which reflect the distance between expectations of policy bodies and advisory services and those of farmers. Moreover, in order to better motivate farmers regarding environmental issues, it is necessary to support and develop actions or tools that also improve the economic and social performance of their operations. This dimension is also often overlooked.

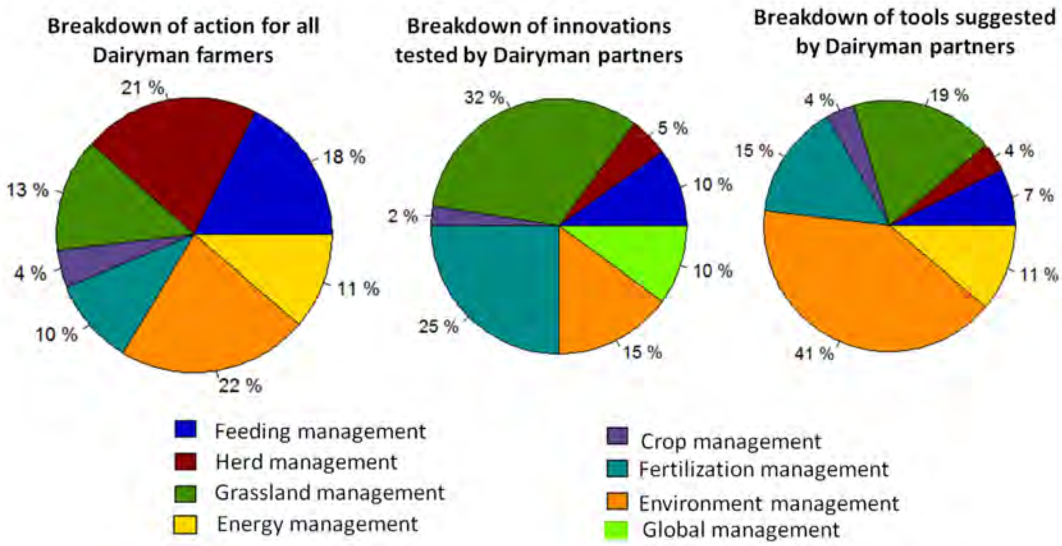

Figure 38. Comparison of farmers' actions and expectations with innovations tested by KTC and tools suggested by research centres involved in the DAIRYMAN project.

Conclusion (H. Kohnen)[14]

The fact that the 130 pilot farmers, from the 10 regions involved in the DAIRYMAN project, agreed to implement an improvement plan to increase sustainability of dairy production demonstrates that farmers want to improve their practices and the performances of their system and that they are prepared to invest time, energy and money to do so.

To reach such a target, the five strategic steps of the DAIRYMAN project were key elements for success:

Step 1: Analysis of the strengths and weaknesses of the region to determine its objectives
Step 2: Analysis of the actual farm situation and performances (general farm description; mineral balance; greenhouse gases and economic performances) to highlight possible farm objectives
Step 3: The farmer presents and develops his personal objectives
Step 4: Line out (a) the most valuable actions and indicators for the objectives, (b) the tools and methods to reach the targets, (c) which local advisory services have to be involved
Step 5: Estimating success of the plan by analyzing evolution of the indicator values

Regional strengths and weaknesses are analyzed through recording region-specific data that must be standardized in order to improve trans-regional analysis and comparison.

DAIRYMAN standardized data recording for the individual pilot farms provided not only homogenous and highly representative data for the individual farms and the network, but also a high profile of the DAIRYMAN community, pilot farms and farmers. Extending standardization to a global EU network should be considered.

Nevertheless, lining out expected results in a short-term project (4 years) is not possible for long-term objectives, for which specific indicators will not improve significantly in a short period of time. Even short-term objectives can completely be annihilated by unpredictable short-term climate or price fluctuations.

Nevertheless, the effectiveness of an individual improvement plan extends far beyond the wish of the farmer. It also depends on the collaboration with local stakeholders. This means that setting up improvement plans must involve close collaboration with local advisory services and dialogue with stakeholders and boost the impact of DAIRYMAN values on local dairy farming.

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Acknowledgment

This is one of the main outputs of the DAIRYMAN project (2009 – 2013). In this NWE INTERREG project 14 organizations of 10 regions cooperated intensively to increase rural welfare by improving resource management of dairy farms and by stakeholder cooperation.

The authors of this report thank the numerous people that contributed but especially the 130 pilot farmers of DAIRYMAN, distributed all over Nord Western Europe. Their farms were used as 'try out' and the resulting experiences and suggestions of these farmers and their advisors were indispensable to realize a really practical manual.

ANNEX 1

FARM DEVELOPMENT PLAN - EXAMPLE

Example of complete farm development plan

In this section, we will present the Farm Development Plan of Rowreagh Dairy Farm, owned by the Steele Family, and one of 10 DAIRYMAN Pilot Farms in Northern Ireland. The Agri-food and Biosciences Institute (AFBI) is the DAIRYMAN regional Partner in NI, and the College of Agriculture, Food and Rural Enterprise is a sub-partner in the project and provide most of the advice and training to farmers involved the project. Together, staff from both institutions worked with Thomas to prepare a Development Plan for his farm towards the end of 2010.

DAIRYMAN

FARM DEVELOPMENT PLAN: 2011-2013

(June 2011 – Revised Oct 2011 – Updated Oct 2012)

FARMER: Mr. Thomas Steele

32 Rowreagh Rd, Kircubbin, Co. Down, BT22 1AS

UK Dairy Farmer of the Year 2012

afbi Agri-Food and Biosciences Institute

cafre College of Agriculture, Food & Rural Enterprise

Contents

Section

1. INTRODUCTION

The goal of DAIRYMAN is to strengthen rural communities in North Western Europe by enhancing the competitiveness of the dairy farming sector and improving its ecological performance. To help achieve this goal, a network of 130 commercial pilot dairy farms has been established across Europe to test and demonstrate new ideas for improving the sustainability of dairy production, and to serve as focal points to inspire other local dairy farmers.

In Northern Ireland, a sub-network of pilot farms has been established, and staff in AFBI and CAFRE are now working closely with each of the pilot farmers to make beneficial changes and improvements to their dairy production systems.

This plan describes your farm and its associated dairying enterprise, and then lists some farm business and environmental objectives that are considered of importance for the region. In discussions with your CAFRE Advisor, you have selected a number of these objectives which you consider to be most relevant to your farm business, and have agreed some target values for the associated indicators. These target values you will aim to achieve during the life-span of the project – i.e. 2011-2013. The measures needed to achieve the various targets are also listed, together with an agreed implementation strategy and timeframe.

Please make every effort to implement the various measures listed in the plan during the next 12 months. In June 2012, a review will be carried out to determine the extent to which targets have been met during this first year, and to decide if additional actions or measures are needed in the following year to fully achieve the targets.

On behalf of the AFBI/CAFRE DAIRYMAN team, I want to thank you for participating in this inter-regional project, and we trust that it will prove to be a rewarding experience for you and your family, and, above all, of benefit to your farm business.

Dr J.S Bailey [15]
AFBI - DAIRYMAN NI Sub-Coordinator

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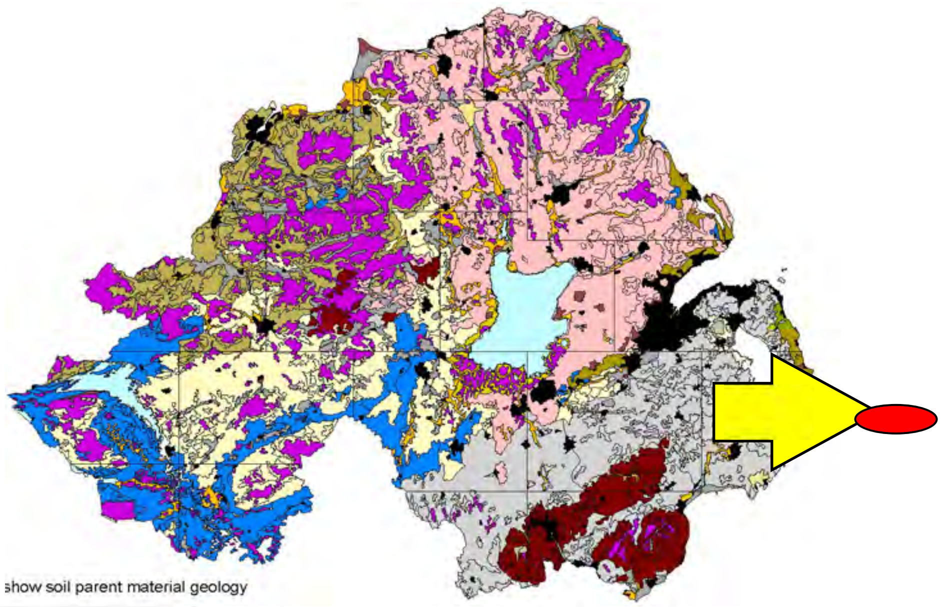
2 FARM PORTRAIT

Data year 2010 Agricultural Area: 255.5 ha			
			(units)
Family	Family Labour	9600	(hours/year)
	Holidays	15	(days/year)
	Employed workforce	17500	(hours/year)
	Work done by contractor	1000	(hours/year)
Soil and climate	Soil Type	Clay loam	
	Annual Rainfall	784	(mm)
	Altitude	6.6	(M)
Land and crops	Grassland	172	(ha)
	Maize	41.5	(ha)
	Wheat	30	(ha)
	Barley	0	(ha)
	Biodiversity scheme	12	(ha)
Livestock	Dairy Cows	390	(number)
	Breed	Holstein/Friesian	
	Calves < 1yr	136	(number)
	Heifers 1 -2yr	110	(number)
	Heifers 2+ yr	0	(number)
	Calving - calving interval	418	(days)
	Milk/cow/year	10,200	(kg)
	Concentrate/cow/year	2970	(kg)
Grazing	Period of grazing D & N	31-May	start (dd-mm)
	Period of grazing D & N	01-Aug	end (dd-mm)
	Period of 24hr housing	15-Oct	start (dd-mm)
	Period of 24hr housing	01-Mar	end (dd-mm)
Buildings	Type of stable, capacity	Free stall cubicles	
	Capacity	400	
	Milking system	60 unit rotary	
Slurry storage	Slurry storage capacity	9091	(m3)
	Slurry storage capacity	6.5	(month)
Manure storage	FYM storage capacity	0	(m3)
	FYM storage capacity	0	(month)
Non-agric. activities	Wind Turbine	No	(kW)
	Solar panels	No	



The Steele's farm 255 hectares of land on the Ards peninsula in County Down. The dairy herd consists of 390 Holstein cows, and a new rotary parlour has recently been installed. The production system relies on high quality silage and grazing to maintain yields and overall performance. Some 42 hectares of forage maize are grown and a further 30 hectares of cereals – the latter either grain or for whole-crop silage. The lower yielding cows graze from March to October, and the higher yielders are housed throughout the year. The winter diet consists of a TMR system with cows topped up with concentrates in the parlour.

Current herd performance is 10,200 litres per cow on 3 tonnes of concentrates per year (>3500 litres/cow from forage). Cows are housed in 2 groups for feeding and management purposes. The new parlour facilitates feeding to yield, and cow body weight is continually monitored to ensure dietary requirements are met. In Northern Ireland this dairy enterprise would be viewed as a high-output system. Key farm business objectives are to enhance profitability via improved feed

efficiency and herd genetics, to improve energy efficiency (e.g. by increasing use of 'night-rate' electricity) and to reduce workload.
The relatively high area of cropping, coupled with a limited export of slurry, ensures that the livestock manure loading is kept under 170 kgs N/ ha. As the farm has a relatively low P balance (4.2 kg P/ha), environmentally the focus is on reducing greenhouse gas emissions, and specifically, methane emissions.

Mineral Balance Summary 2010				
INPUTS	Source	N (kg/ha)	P (kg/ha)	K (kg/ha)
	Animals	0.0	0.0	0.0
	Mineral Fertilizer	146.0	1.9	4.9
	Organic Fertilizer	0.0	0.0	0.0
	Plant Products (FR, cereals,...)	0.0	0.0	0.0
	Feed concentrates	192.1	23.3	60.8
	Biological N fixation	3.1	0.0	0.0
	Atmospheric deposition	7.4	0.0	0.0
	TOTAL INPUT	348.6	25.2	65.6
OUTPUTS	Source	N (kg/ha)	P (kg/ha)	K (kg/ha)
	Milk	83.9	14.9	23.6
	Animals	6.2	1.8	0.5
	Other Outputs	0.3	0.1	0.6
	Organic Fertilizer	8.5	1.5	7.6
	TOTAL OUTPUT	98.9	18.3	32.3
STOCK VARIATION	Source	N (kg/ha)	P (kg/ha)	K (kg/ha)
	Animals	0.0	0.0	0.0
	Mineral Fertilizer	0.0	0.0	0.0
	Organic Fertilizer	0.0	0.0	0.0
	Plant Products (FR, cereals,...)	0.0	0.0	0.0
	Feed concentrates	0.0	0.0	0.0
	TOTAL STOCK VARIATION	0.0	0.0	0.0
		N (kg/ha)	P (kg/ha)	K (kg/ha)
	BALANCE	249.7	6.9	33.3

3 DEVELOPMENT PLAN (DP) OBJECTIVES

Economic Objectives (F)	Priority	Explanation
F1. Enhanced income from farming	High	Ensuring farm sustainability in the present challenging economic climate
F2. Improved energy efficiency	Medium	Reducing farm overhead costs by reducing energy consumption

Social Objectives (S)	Priority	Explanation
S1. Reduced workload	Medium	Farmer likes to spend more time relaxing with his family
S2. Improved management skills		Farming more efficiently and profitably should lower stress and increase enjoyment

Environmental Objectives (E)	Priority	Explanation
E1. Lowered potential for P leaching/runoff		Helping to meet the objectives of the EU Nitrate Directive and Nitrates Action Programme
E2. Better ecological quality of surface water		Helping to meet the objectives of the EU Water Framework Directive
E3. Reduced potential for ammonia (NH_3) and nitrous oxide (N_2O) emissions		Helping the UK to reduce ammonia emissions in accordance with the Gothenburg protocol, and N_2O emissions in accordance with the NI target for a 25% reduction in GHG emissions by 2025
E4. Reduced potential for methane (CH_4) emissions	Medium	Helping to meet the NI target for a 25% reduction in GHG emissions by 2025

4 INDICATORS AND TARGETS TO ACHIEVE OBJECTIVES

F1. Enhanced income from farming

Indicator	Unit	Actual value	Attainable value	Target value
Feed efficiency	*concentrate/litre*	0.32	0.25	0.29
Cow replacement rate	*%*	36.74	20	25

F2. Improved energy efficiency

Indicator	Unit	Actual value	Attainable value	Target value
Energy use	*kW/ton milk*	36	28	32
Night saver electricity use	*%*	24.2	80	50

S4. Reduced workload

Indicator	Unit	Actual value	Attainable value	Target value
Reduced working hours	*Hours/week*	66	50	60
Increased vacation time	*Free days/year*	15	25	20

E4. Reduced potential for methane (CH_4) emissions

Indicator	Unit	Actual value	Attainable value	Target value
Forage quality	*ME*	12.8	12-13	Maintain
Cow replacement	*Lactation no*	36.74	20	25
Calving interval	*interval in days*	418	380	400

† *value unavailable at present but will be estimated retrospectively for 2010.*

5 MEASURES TO MEET TARGETS

F1. Measures to enhance income from farming

Measure	Effect on what?	Disadvantages	Implementation
F1a. Improve feed efficiency through avoiding feed wastage to low yielding and late lactation cows	Profit per cow Concentrate feeding rate per litre Milk from forage, Farm P balance	May slightly reduce herd average milk output	Batch cows according to stage of lactation and/or feed a higher proportion of concentrates in the milking parlour Targeting of higher performance cows in herd.
F1b. Adjust computerized concentrate feeding programmes to take account of yield, cow condition and forage quality on a regular basis	Profit per cow Concentrate feeding rate per litre Milk from forage Farm P balance	Farm has adopted relevant technology.	Attend training courses organized by CAFRE and milking parlour equipment suppliers in 1st or 2nd year Assess appropriateness of computer feeding settings applied in different seasons. Work has commenced in 2010 and on-going.
F1c. Select sires with high £PLI, Fertility Index (FI) and Lifespan (LS) Predicted Transmitting Abilities (PTA's)	Improved cow profitability Cow replacement rate (reduced)	Long timescale to take effect but can be assessed through herd genetic summaries available for the farmer if milk recording is taking place	Commence implementation in 1st year.

F2. Measures to improve energy efficiency

Measure	Effect on what?	Disadvantages	Implementation
F2a. Benchmark energy use	Electricity use and costs	Analysis of records	Implementation in 1st year
F2b. Convert to night saver electricity tariff	Electricity costs		Implementation in 1st year
F2c. Installation of Heat recovery system	Electricity costs	Capital cost of equipment	Implementation in 2nd year

S1. Measures to reduce workload

Measure	Effect on what?	Disadvantages	Implementation
S1a. Dairy farm automation with increased IT utilization	Farmer labour input and accuracy of operations	Cost, training requirements and regular management input requirement	E.g. auto ID, parlour feeding, segregation, heat detection. Reduce manual input on farm first year of plan.
S1b. Contract out silage cutting and slurry spreading	Farmer labour input and mechanization costs	Timeliness of contractor operation and contractor availability	Seek to contract out silage cutting and/or slurry spreading work already in place.

E4. Measures to lower the potential for methane emissions

Measure	Effect on what?	Disadvantages	Implementation
E4a. Increase forage quality and digestibility	Reduced enteric CH_4 emission c.f. lower digestibility forage	Insufficient data available locally to indicate if approach is effective relative to a high concentrate/low forage diet	Follow the CAFRE feed efficiency initiative work is on-going.
E4b. Select sires with high £PLI, Fertility Index (FI) and Lifespan (LS) Predicted Transmitting Abilities (PTA's)	Improved cow profitability, longevity and fertility	Long timescale to take effect but can be assessed through herd genetic summaries available for the farmer if milk recording is taking place	Select sires from the top 100 listed by £PLI available in N. Ireland. Work is in place.
E4c. Increase of in-heat detection efficiency through increased observation or investment in automated in-heat detection equipment	Fewer (*not in-calf*) cows culled and shortened calving intervals resulting in lowered CH_4 emissions, reduced infertility costs and higher profit/cow	Investment of time and or capital	Monitor results through analysis of data produced from parlour software. Work is on-going.

6 FARM PERFORMANCE AFTER (DP) IMPLEMENTATION

It is very important that the success of the Farm Development Plan is monitored over the project period. This part describes the progress Thomas has made to date in meeting the targets agreed in his Plan.

As you can see, already, Thomas has fully achieved his target of reducing concentrate inputs per litre of milk to just 0.29 kg. He may therefore decide to set a new target for 2012.

As regards the other targets, most are well on the way to being fully achieved. The only exception being the energy target, but as has already been pointed out, the heat recovery system needed to help reduce energy consumption, was only installed this year, so its impact will not be noted until next year.

F1. Performance after implementation of measures to enhance farm income

Indicator	Unit	Target	2010	2011	Comments
Feed efficiency	*concentrate/litre*	0.29	0.32	0.29	✓✓ Fully achieved
Cow replacement rate	*%*	25	36.74	28.9	✓ 68% achieved

F2. Performance after implementation of measures to improve energy efficiency

Indicator	Unit	Target	2010	2011	Comments
Energy use	*kW/ton milk*	32	36	37	Heat recovery system only installed 2012
Night saver electricity use	*%*	50	24.2	?	2011 data not available

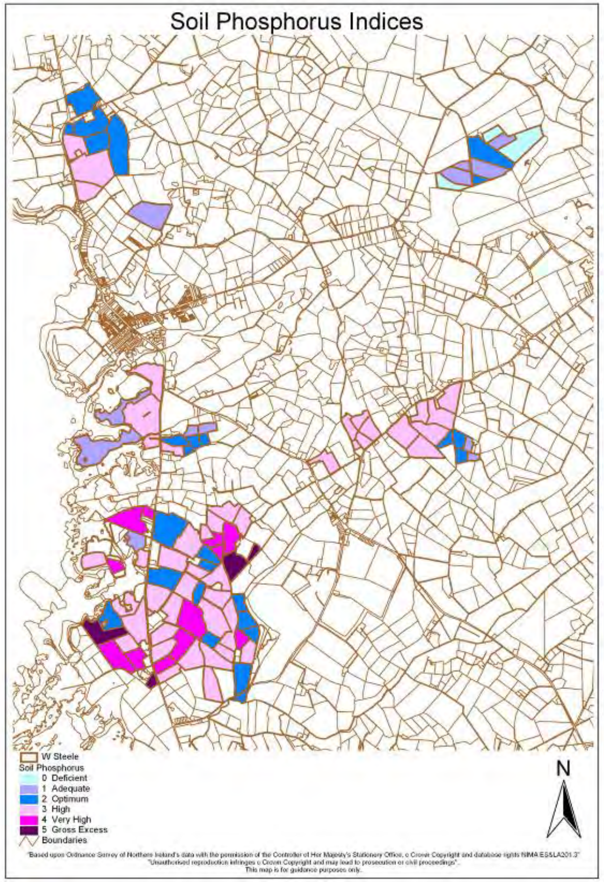
S1. Performance after implementation of measures to reduce workload

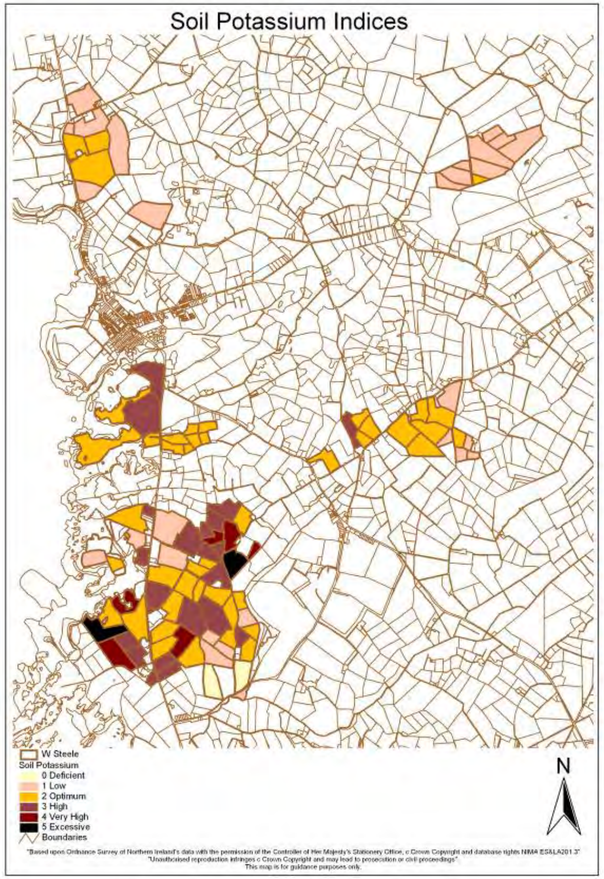
Indicator	Unit	Target	2010	2011	Comments
Reduced working hours	*Hours/week*	60	66	63	✓ 50% achieved
Increased vacation time	*Free days/year*	20	15	17	✓ 50% achieved

E4. Performance after implementation of measures to lower methane emission

Indicator	Unit	Target	2010	2011	Comments
Forage quality	*ME*	12-13	12.8	12	✓ Achieved
Cow replacement	*%*	25	36.74	28.9	✓ 68% achieved
Calving interval	*interval in days*	400	418	410	✓ 44% achieved

APPENDIX 1
SOIL NUTRIENTS





APPENDIX 2
HERBAGE NUTRIENTS

Grazing Fields – Grass Analyses – 2010

April

Field No.	N %	P %	K %	S %	Ca %	Mg %	Na %	Protein %
3/5/105/10	2.88	0.322	2.71	0.208	0.371	0.181	0.285	18.0
3/5/81/1	2.76	0.363	3.53	0.211	0.368	0.154	0.132	17.3
3/5/81/3+4	2.67	0.349	3.55	0.218	0.379	0.188	0.135	16.7
3/5/91/3	2.72	0.374	3.44	0.218	0.472	0.167	0.134	17.0
3/5/91/4	2.80	0.332	3.36	0.202	0.388	0.148	0.236	17.5
3/5/94/3	2.74	0.356	3.57	0.201	0.432	0.130	0.173	17.1
3/5/97/2	3.40	0.277	1.69	0.219	0.468	0.273	0.508	21.3
3/5/97/4	3.66	0.337	2.00	0.229	0.454	0.298	0.513	22.9
3/5/98/1	3.51	0.335	3.00	0.211	0.405	0.193	0.166	21.9
3/5/98/10	2.87	0.272	3.05	0.236	0.449	0.186	0.306	17.9
3/5/98/11	2.79	0.286	3.13	0.228	0.440	0.165	0.193	17.4

June

Field No.	N %	P %	K %	S %	Ca %	Mg %	Na %	Protein %
3/5/105/2	3.06	0.181	2.06	0.287	0.519	0.213	0.420	19.1
3/5/105/9	2.56	0.307	2.23	0.293	0.381	0.215	0.347	16.0
3/5/45/3	2.86	0.247	1.98	0.226	0.471	0.223	0.405	17.9
3/5/81/1	2.61	0.284	2.96	0.246	0.413	0.164	0.170	16.3
3/5/94/5	3.02	0.221	2.37	0.243	0.537	0.186	0.437	18.9
3/5/98/1	1.92	0.231	2.46	0.172	0.408	0.184	0.213	12.0

August

Field No.	N %	P %	K %	S %	Ca %	Mg %	Na %	Protein %
3/5/105/1	4.03	0.330	3.23	0.295	0.585	0.236	0.320	25.2
3/5/105/10	3.75	0.347	3.15	0.351	0.472	0.228	0.240	23.4
3/5/105/2	3.95	0.338	3.26	0.297	0.604	0.225	0.316	24.7
3/5/81/1	3.46	0.366	3.70	0.296	0.428	0.199	0.219	21.6
3/5/81/3+4	3.39	0.363	3.67	0.325	0.416	0.208	0.153	21.2
3/5/98/1	3.28	0.287	3.05	0.267	0.428	0.207	0.210	20.5

September

Field No.	N %	P %	K %	S %	Ca %	Mg %	Na %	Protein %
3/5/105/2	3.82	0.354	3.70	0.308	0.506	0.220	0.423	23.9
3/5/105/4	4.02	0.340	3.30	0.343	0.598	0.245	0.514	25.1
3/5/105/7	3.27	0.387	2.22	0.313	0.615	0.239	0.596	20.4
3/5/105/9	3.38	0.404	3.22	0.339	0.525	0.249	0.570	21.1
3/5/50/1	2.66	0.326	2.27	0.494	0.591	0.287	0.656	16.6

Herbage, at prime grazing stage, ideally should contain >2.5% N, >0.3% P, 1.75 to 3.0% K, >0.2% Mg, and >0.3% Na

- If N contents fall below 2.5% in the DM, the protein requirements of grazing ruminants may not be met.
- If P contents fall below 0.3% in the DM, while grass growth may not be affected, P requirements for animal production may not be met.
- The K contents of herbage need to be maintained above 1.75% in the DM to ensure optimal grass growth – however, if they exceed 3%, Mg and Na levels may be detrimentally lowered.
- If Mg concentration falls below 0.2%, e.g. because of an over-supply of K or an under-supply of Mg, the risk of grass tetany in spring is significantly increased.
- If Na concentration falls below 0.3% in the DM, grass palatability may be reduced; and if it falls below 0.15%, Na requirements for lactating dairy cattle may not be met. The main reason for low Na levels is an excess supply of K, rather than a drop in atmospheric inputs from rainfall.

Silage Fields – Grass Analyses – 2010

Cut 1 (April)

Field No.	DRIS N	DRIS P	DRIS K	DRIS S	N %	P %	K %	S %	Ca %	Mg %	Na %	Protein %
3/5/105/3	27	10	7	16	3.70	0.331	2.57	0.327	0.581	0.208	0.387	23.1
3/5/105/7	29	16	8	13	3.35	0.339	2.43	0.279	0.552	0.168	0.439	20.9
3/5/105/8	36	10	17	18	3.33	0.271	2.67	0.275	0.435	0.163	0.326	20.8
3/5/105/9	40	22	11	**-6**	3.64	0.372	2.70	0.203	0.463	0.218	0.400	22.8
3/5/108/1	31	35	33	8	3.13	0.444	3.86	0.238	0.422	0.168	0.088	19.6
3/5/110/129 B	24	15	19	14	2.99	0.316	2.89	0.261	0.473	0.169	0.361	18.7
3/5/21/1	36	13	16	17	3.33	0.291	2.63	0.272	0.446	0.162	0.349	20.8
3/5/34/2	16	17	17	12	2.80	0.355	2.96	0.260	0.588	0.156	0.303	17.5
3/5/34/5	25	15	16	17	3.16	0.336	2.87	0.289	0.538	0.158	0.351	19.8
3/5/34/6	26	15	7	15	3.26	0.337	2.38	0.288	0.552	0.176	0.437	20.4
3/5/45/1	37	23	17	**-3**	3.46	0.374	3.03	0.206	0.514	0.170	0.278	21.6
3/5/50/1	39	16	24	9	2.89	0.266	2.71	0.203	0.366	0.143	0.258	18.1
3/5/50/11	32	14	23	7	2.44	0.232	2.46	0.175	0.378	0.118	0.296	15.3
3/5/50/5	43	16	26	**3**	2.73	0.241	2.62	0.168	0.372	0.118	0.163	17.1
3/5/81/2	38	24	15	13	3.73	0.401	2.93	0.288	0.476	0.186	0.395	23.3
3/5/81/6	34	23	16	14	3.57	0.397	2.99	0.292	0.493	0.177	0.353	22.3
3/5/91/20	35	14	20	13	3.53	0.326	3.19	0.275	0.554	0.153	0.229	22.1
3/5/91/30	35	20	16	14	3.35	0.348	2.76	0.268	0.490	0.154	0.358	20.9
3/5/94/6	26	19	27	10	3.09	0.359	3.63	0.247	0.542	0.150	0.202	19.3
3/5/94/8	46	20	17	**0**	3.53	0.321	2.76	0.206	0.395	0.188	0.374	22.1

When a DRIS Index is <5 the nutrient in question is in low supply; but when the index drops to negative values, ≤0, the nutrient in question is deficient and limiting to sward production and corrective action should be taken for subsequent silage crops.

Silage Fields – Grass Analyses – 2010

Cut 2 (June)

Field No.	DRIS N	DRIS P	DRIS K	DRIS S	N %	P %	K %	S %	Ca %	Mg %	Na %	Protein %
3/5/105/7	28	7	-9	0	2.62	0.214	1.23	0.174	0.464	0.183	0.525	16.4
3/5/108/1	2	13	31	13	1.77	0.253	2.98	0.191	0.350	0.163	0.156	11.1
3/5/110/129B	9	15	7	0	1.80	0.244	1.69	0.144	0.377	0.167	0.560	11.3
3/5/21/1	24	11	9	3	2.84	0.279	2.30	0.203	0.482	0.185	0.480	17.8
3/5/34/2	12	9	9	2	2.39	0.266	2.23	0.187	0.533	0.180	0.501	14.9
3/5/34/5	7	13	15	5	1.94	0.256	2.25	0.173	0.420	0.163	0.468	12.1
3/5/34/6	11	13	4	5	2.03	0.249	1.67	0.175	0.410	0.170	0.507	12.7
3/5/45/1	22	13	13	1	2.38	0.251	2.16	0.167	0.389	0.173	0.303	14.9
3/5/50/1	5	1	6	8	2.30	0.225	2.07	0.218	0.518	0.223	0.482	14.4
3/5/50/11	-2	3	9	10	1.98	0.238	2.21	0.219	0.538	0.198	0.634	12.4
3/5/50/5	0	6	12	13	1.98	0.245	2.30	0.225	0.494	0.178	0.436	12.4
3/5/81/2	11	8	4	7	2.46	0.268	1.97	0.219	0.522	0.190	0.445	15.4
3/5/81/6	12	9	-2	4	2.62	0.288	1.75	0.220	0.618	0.198	0.595	16.4
3/5/91/20	0	3	7	-3	2.16	0.255	2.39	0.172	0.715	0.201	0.392	13.5
3/5/91/30	6	7	3	1	2.46	0.290	2.09	0.204	0.668	0.204	0.515	15.4
3/5/94/6	9	6	18	9	2.53	0.275	2.99	0.232	0.548	0.183	0.382	15.8

When a DRIS Index is <5 the nutrient in question is in low supply; but when the index drops to negative values, ≤0, the nutrient in question is deficient and limiting to sward production and corrective action should be taken for subsequent silage crops

Silage Fields – Grass Analyses – 2010

Cut 3 (August)

Field No.	DRIS N	DRIS P	DRIS K	DRIS S	N %	P %	K %	S %	Ca %	Mg %	Na %	Protein %
3/5/110/129B	11	17	2	-4	2.80	0.382	2.29	0.206	0.652	0.229	0.554	17.5
3/5/21/1	14	12	9	14	3.02	0.348	2.65	0.297	0.570	0.215	0.496	18.9
3/5/34/2	7	15	4	4	2.66	0.374	2.35	0.239	0.696	0.206	0.505	16.6
3/5/34/5	12	11	9	4	2.85	0.332	2.63	0.233	0.643	0.199	0.486	17.8
3/5/34/6	13	9	-6	7	2.99	0.321	1.75	0.269	0.703	0.218	0.561	18.7
3/5/45/1	10	9	5	6	2.81	0.321	2.42	0.249	0.646	0.215	0.406	17.6
3/5/50/1	5	4	3	20	2.64	0.277	2.06	0.328	0.542	0.244	0.552	16.5
3/5/50/11	3	10	5	18	2.47	0.327	2.20	0.305	0.553	0.222	0.682	15.4
3/5/50/5	2	8	9	19	2.55	0.317	2.54	0.319	0.586	0.219	0.454	15.9
3/5/81/6	8	16	5	9	2.84	0.397	2.51	0.281	0.665	0.211	0.469	17.8
3/5/91/20	8	2	7	1	3.04	0.295	2.79	0.238	0.881	0.215	0.295	19.0
3/5/91/30	15	14	7	9	3.04	0.364	2.56	0.270	0.605	0.203	0.413	19.0

Cut 4 (September)

Field No.	DRIS N	DRIS P	DRIS K	DRIS S	N %	P %	K %	S %	Ca %	Mg %	Na %	Protein %
3/5/110/129B	19	26	8	5	3.12	0.443	2.63	0.256	0.514	0.233	0.817	19.5
3/5/21/1	19	13	9	21	3.31	0.355	2.63	0.349	0.529	0.219	0.668	20.7
3/5/34/2	9	19	7	7	2.95	0.436	2.77	0.279	0.629	0.233	0.522	18.4
3/5/34/5	16	17	12	10	3.25	0.405	3.08	0.294	0.592	0.223	0.564	20.3
3/5/34/6	13	10	-2	8	3.30	0.369	2.18	0.300	0.694	0.257	0.764	20.6
3/5/91/20	12	7	9	8	3.21	0.331	2.90	0.284	0.707	0.220	0.350	20.1
3/5/91/30	17	17	10	5	3.33	0.415	3.00	0.270	0.613	0.232	0.610	20.8

When a DRIS Index is <5 the nutrient in question is in low supply; but when the index drops to negative values, ≤0, the nutrient in question is deficient and limiting to sward production and corrective action should be taken for subsequent silage crops

APPENDIX 3
GREENHOUSE GAS (GHG) EMISSIONS

IPPC Tier 2 GHG losses from T. Steele's farm in 2009*			
	kg CO_2-equivalent per hectare	kg CO_2-equivalent per ton of milk	%
ANIMAL			
Methane	6217	444.8	48
MANURE			
Methane	1415	101.2	11
Direct N_2O	216	15.4	2
Indirect N_2O	287	20.6	2
SOIL			
Direct N_2O	3426	245.1	26
Indirect N_2O	218	15.6	2
CO_2	1292	92.5	10
TOTAL GHG	13072	935	100
- from CO_2	1292	92	10
- from CH_4	7632	546	58
- from N_2O	4147	297	32

* *Excluding those from energy use, nitrogen fertilizer production and purchased feed*
Including indirect emission from managed soils

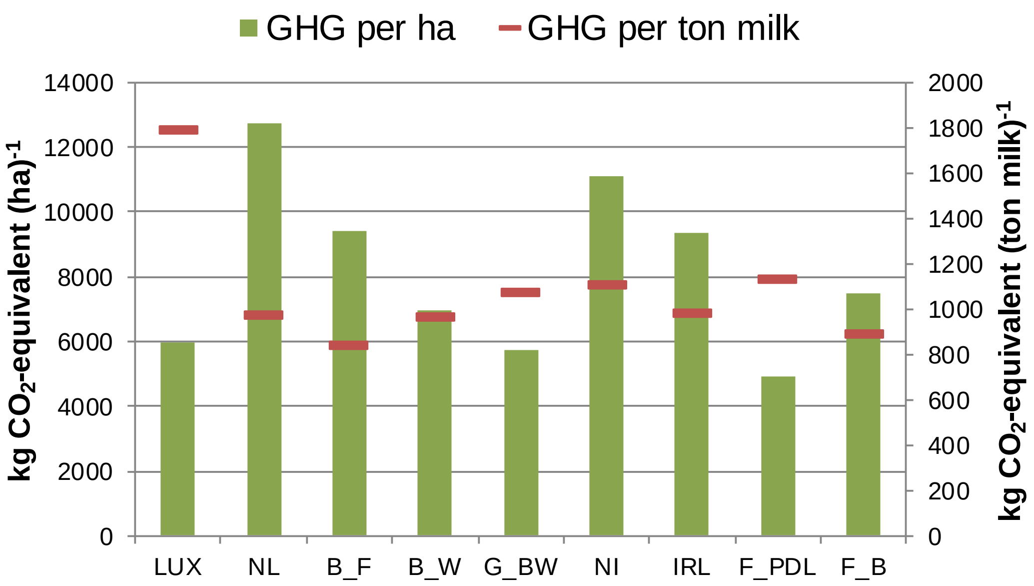


Figure 39. GHG Emissions from Average Regional Farms in Europe.

APPENDIX 4
THE RATIONALE FOR ENVIRONMENTAL MEASURES

E1. Measures to lower the potential for P leaching/runoff from agricultural land

E1a. If forage production can be improved by rejuvenating less productive swards (e.g. by liming and reseeding) where loss of ryegrass (*invasion by other grass and weed species*), and or compaction may have lessened productivity, the improved yield and quality of the resulting forage or grazed swards should enable reductions to be made in concentrate purchase. Because concentrate purchase represents a net import of phosphorus to the farm (*in the P-containing feedstuffs*), reducing such purchases will lower the farm P balance and hence the potential for P leaching and runoff from agricultural land.

E1b. More than 20% of silage swards at cut 1 have been shown to be deficient in sulphur, even when substantial amounts of slurry have been applied. This deficiency can lower forage yield by up to 40%. Some years this deficiency is worse than in others, e.g. S deficiency in 2009 was much more severe than in 2010. It is difficult to predict in advance whether or not S deficiency will be severe. As a risk aversion strategy, therefore, it is good practice to use a S-containing fertilizer for all 1^{st} cut silage crops, since this will guarantee that you suffer no yield penalties. The S added for 1^{st} cut will have a carry-over effect to 2^{nd} cut crops, thus ensuring no S deficiency at 2^{nd} cut either. By preventing declines in forage yield due to deficiency, concentrate purchases for winter housed stock may be reduced, thus bringing about reductions in the farm P balance.

E1c. Many intensive dairy farms have a significant percentage of silage fields with soil P indices of 4 and 5. Soils at P index 4 and 5 are likely to release more P into land drainage water than those at index 2 and 3. It is good practice to reduce the amounts of slurry applied to these high P index soils to lower the soil P index level, and seek to apply more slurry to soils with P indices of 1 and 2. Often fields with P indices of 1 and 2, have low soil K indices also (index 0 and 1). At these low K indices, swards can suffer from K deficiency which can significantly lower silage yield. Instead of investing in expensive K-containing fertilizers to correct this problem, it makes sense to apply more slurry to these fields, thereby correcting a K problem, while at the same time helping to lower the excessively high soil P levels (index 4 & 5) in other fields.

E1d. The current NI Nitrates Action Programme allows slurry spreading to recommence in February. However, studies have shown that there is a high risk of P runoff from slurry if applied in this month. This is because across much of NI, soil moisture levels are at saturation level during both January and February, hence additional rainfall doesn't soak into the ground, but runs off into streams etc. In contrast, from March onwards, as grass growth commences and as water is taken up by plants, soils begin to dry out, and hence the risk of P runoff from applied slurry is lessened. It is good practice therefore, to try and apply most of your slurry between March and the end of May, and avoid the February period if at all possible.

E2. Measures to improve the ecological quality of surface waters

The ecological quality of water is basically assessed from the amounts and types of different living organisms (*invertebrates*) present in brooks, streams or rivers. It is NOT a mandatory requirement under EU legislation to maintain or improve the ecological quality of water, but it is satisfying (*for environmentally conscious farmers*) to have streams running through your farm capable of supporting a wide range of aquatic life including small fish, water beetles, newts etc. If you wish to sign up to this measure, AFBI scientists will sample a stream as it enters your land and again as it leaves your land to see if the invertebrate score remains as high, increases (*owing to improvements in water quality*), or decreases (*owning to decreased water quality possibly linked to pollution*) on passing through your farm.

E2a. A major source of stream pollution is dirty water from farmyards which has high levels of ammonium. Yard improvement plans can minimize the amount of dirty water entering storm drains and reaching streams and rivers.

E2b. Soils at P index 4 and 5 are likely to release more P into land drainage water than those at index 2 and 3. Lowering the percentage of farm land with high P index (*index 4 and 5*) soils by redistributing slurry to land with lower soil P (*index 1 and 2*) and soil K (*index 0 and 1*) indices (*see **E1c)*** should reduce the potential for P runoff into streams and lead to improved water quality.

E2c. Constructed wetlands, e.g. the wetland at CAFRE Greenmount campus, which treats dirty water from the dairy farm, can significantly reduce the amount of dirty water reaching streams or waterways. Your CAFRE Advisor can give you further information about this technology.

E2d. During the autumn when soils are warm and beginning to rewet after the summer, ammonium nitrogen in slurry and manure can be converted into nitrate, which in turn can be leached into groundwater and streams. It is good practice therefore to apply most slurry or manure between March and May and very little if any from September onwards (*see **E1d***). Taking this measure should reduce the risk of nitrate entering waterways on your farm.

E3. Measures to lower the potential for NH_3 and N_2O emissions from farmland

E3a. In NI, most slurry is spread by splash plate and as a consequence much of the available ammonia N is lost to the atmosphere. Ammonia losses can be significantly lowered by reducing the time that slurry is in contact with air by applying slurry in bands on the soil surface or by using a trailing shoe. The standing forage helps to absorb odour and ammonia. A three-year study at AFBI Hillsboro demonstrated that using band spreading or trailing shoe increased forage dry matter yields by 18% and 26%, respectively, compared to spreading with inverted splash plate. Using band spreading or trailing shoe lowered the N requirement of the crop by 44 kg N/ha, owing to reduced losses of ammonia N to the atmosphere. Using these technologies therefore not only helps to reduce ammonia pollution, but it will also help to improve production or reduce the amount of N fertilizer needed to achieve optimum production.

E3b. In NI, particularly after the 1st cut, slurry and fertilizer N are applied almost simultaneously. Slurry, however, has a rich supply of carbon, which allows bacteria to convert fertilizer nitrate N to the potent greenhouse gas (GHG) nitrous oxide. Studies by AFBI have shown that applying fertilizer N at least 4 days after slurry application, when the slurry carbon has been absorbed by the soil, significantly reduces the amount of N lost as nitrous oxide.

E4. Measures to lower the potential for methane emissions

E4a. When dairy cows are offered diets which contain high levels of fibre (*lower quality diets*), the resulting fermentation pattern within the rumen tends to result in high methane outputs. Correspondingly, improving the quality of the diet (i.e. offering higher ME diets) will result in lower methane emissions.

E4b. During the 24 month period it takes to rear a dairy heifer, the heifer produces methane. While this is an inevitable consequence of the heifer rearing process, minimizing the number of heifers on the farm by reducing overall replacement rates will have the effect of reducing total methane emissions from a dairy system.

E4c. Most evidence indicates that in terms of milk production efficiency, having a calving interval of approximately 370 days is optimum for overall financial performance. Thus it follows that moving towards this optimum will also minimize the methane emissions per litre of milk produced.

E4d. Pasteurization of milk fed to young heifer calves minimizes the risk of bacterial infections in their digestive tracts, thus improving their performance and productivity in adulthood, which in turn reduces methane emission per litre of milk produced.

ANNEX 2
NUTRIENT VALUES

Table 22. Type of animal with their mineral content in kg/t.

Type of animal	N content (kg/t)	P content (kg/t)	K content (kg/t)
Milking cows	24	7	2
Calves (<1/2 yr)	24	7	2
Calves (1/2 yr -1yr)	24	7	2
Heifers (1yr -1.5 yrs)	24	7	2
Heifers (1.5yrs -2yrs)	24	7	2
Heifers (>2yrs)	24	7	2
Breeding Bulls	24	7	2
Suckler Cows	24	7	2
Calves (<1/2 yr)	24	7	2
Calves (1/2 yr -1yr)	24	7	2
Cattle (1yr -1.5 yrs)	24	7	2
Cattle (1.5yrs -2yrs)	24	7	2
Cattle (>2yrs)	24	7	2
Breeding Bulls	24	7	2
Sheep	26	6	1.9
Horses	27	7.5	2
Poultry	27	4.6	2

Table 23. Type of plant product with percentage dry matter and mineral content in kg/t.

Type	Dry Matter (%)	N content (kg/t)	P content (kg/t)	K content (kg/t)
Grass silage	40	25	4.4	24.9
Maize silage	32	4,3	0.8	4.2
Hay	83	18	3.05	20
Straw	86	5	1.3	13
Wheat	86	18	3.5	5
Barley	86	17	3.5	5
Oat	86	15	3.5	5
Grain maize	86	15	3	4
Rye	86	15	3.5	5
Beans	86	41	5.2	11.6
Peas	86	36	6.1	11.6
Colza	91	33.5	7.8	8.3
Potatoes	22	3.5	0.61	4.98
Grapes		2.2	2	3.7

Within DAIRYMAN 14 partners cooperate:
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Plant Research International , Netherlands
Wageningen UR Livestock Research, Netherlands
Teagasc, Ireland
Agri-Food and Bioscience Institute (AFBI), United Kingdom (Northern Ireland)
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