COLLECTION
DOSSIERS TECHNIQUES
DE L'ÉLEVAGE

N°6

Dairy 4 future

SEPTEMBRE 2022

FOR MORE RESILIENT DAIRY FARMING IN THE ATLANTIC AREA

Lessons from Dairy 4 Future project

Description
The dairy sector in the Atlantic area

Initiatives
Rendered services by dairy farming, a road for added value?

Solutions
The pilot farms network: 100 dairy farmers on the road to efficiency

Perspectives
Research contributions to propose reference systems or improvement measures


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Interreg Atlantic Area – European Regional Development Fund – European Union
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INRAE · AHDB – Agriculture & Horticulture Development Board · neiker tecnalia · Axencia Galega da Calidade Alimentaria · SRUC · Instituto Superior de Agronomia – Universidade de Lisboa

EDITO

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From Scotland to the Azores, dairy production is a major economic activity in the Atlantic area. This dairy area, located in the extreme west of Europe with soil and climate conditions suitable to forage production and grazing, represents 23% of European milk production. It also includes 80,000 dairy farms and 100,000 farmers and employees and employs 70,000 people in dairy companies, ensuring vitality and added value to the various territories.

Since the end of the quota system, the dairy sector in the Atlantic area is even more affected by the opening up of markets, and therefore higher price volatility, due to its exposure to dairy commodities. This context requires improved efficiency and resilience of dairy systems. In addition, the dairy sector must also assure appropriate use of resources (feed, water, energy, fertilizers,…) and reduce its environmental impacts, in particular greenhouse gas emissions, in line with internal commitments and European objectives ("fit for 55": -55% in 2030/1990). All the dairy regions of the Atlantic area seaboard must also tackle the renewal of the workforce, which requires strengthening the dairy sector attractivity.

The Dairy 4 Future project was born in this context, supported by ERDF funds, in the framework of Interreg Atlantic Area. This project aimed to improve socio-economic resilience and sustainability of the dairy sector, through the development of innovative and efficient dairy systems, and improved cooperation between partners. It thus brought together 11 research/development partners, from 12 dairy regions from the 5 countries of the Atlantic area. For five years (2018-2022), the project has brought together engineers, advisors and over one hundred pilot farmers to develop more efficient, resilient, and low environmental impact systems through shared experience, and the comparison of ideas and systems.

This Dairy 4 Future project is also a continuation of several European projects aimed at improving competitivity of dairy sector: Green Dairy (Interreg Atlantic area, 2003-2006), Dairyman (Interreg North West Europe, 2009-2013), Autograssmilk (FP7, 2013-2015), EuroDairy (Horizon 2020, 2016-2018), and Resilience-4-Dairy (2021-2023). These various projects facilitate strengthening of cooperation between R&D organizations allowing swift and reliable solutions to improve competitivity and to build European identity.

Since this project commenced in 2018, several unforeseen events occurred that were not expected the set-up phase: Brexit, which impacted trade relations between countries; COVID, which reinforced the notion of food sovereignty; and the war in Ukraine, which amplified the rise in prices for raw materials (food, energy, fertilizers, …). Moreover, climate change has become a reality. All these events have only reinforced the need for efficient and resource-saving dairy production, aiming at climate neutrality. Elements provided in this document, from grazing systems to indoor systems, adopt this perspective: the contents will help guide the transformation of dairy systems within these regions, brushed by Atlantic winds. The Atlantic area, with its climate and its farmers, is equipped with assets to remain a major dairy area at the international level.

FOREWORD

Economic competitiveness, resilience, sustainability, resource efficiency, environmental footprint... How can the dairy sector in the Atlantic area meet the major challenges it is already facing? These are the major challenges that the Interreg Dairy 4 Future project had deployed in 5 countries and 12 regions of the Atlantic area between 2018 and 2022. Find in this edition of the « Dossiers Techniques de l'Élevage » the main results and lessons learnt from this project.

Dairy 4 future
Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION

SUMMARY

FOREWORD

"Dairy 4 Future project focused on four key issues: analyse the strengths and weaknesses of the dairy sector in Atlantic area, foster dairy sector economic resilience, improve resource use efficiency and determine sustainable dairy systems for the future."

Sylvain FORAY,
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- Institut de l'Élevage (France)

• TO GO FURTHER

> **CLIMATE CHANGE AND LAND. IPCC, 2019.** Download on: www.ipcc.ch/srccl/

> **THE MAJOR CHALLENGES – IS THERE STILL TIME TO SAVE OUR PLANET?** FAO, Coll. The state of the planet, 2017.

> **FARM TO FORK STRATEGY: FOR A FAIR, HEALTHY AND ENVIRONMENTALLY-FRIENDLY FOOD SYSTEM.** European Commission Read more on: https://food.ec.europa.eu/

What does the dairy sector represent in the Atlantic area?

In the Atlantic area, dairy production represents a major economic activity. About 23% of the milk production of the European Union (including United Kingdom) is produced in this area by around 80,000 farms and 100,000 farmers and farm workers.
In 2010, the volume of milk produced in the Atlantic area, from the west coasts of the United Kingdom, France and Portugal (including the Azores), Ireland and Northern Ireland and north-western Spain, was 34.8 million tonnes (155 million for the EU28). Ten years later, European milk production has increased by about 12% (174 million tonnes produced). This increase has been 18%... overall in the Atlantic area, with disparities between regions (+54% in Ireland, +11% in Brittany, +1% in the Spanish Basque Country).
Moreover, in this area, the dairy industry generates 70,000 jobs.

What are the characteristics that facilitate milk production in the Atlantic area?

Climatic conditions and soil quality make the Atlantic area one of the most favourable locations in the world for milk production. All the regions of the Atlantic area are influenced by an oceanic climate with contrasting climatic situations. The West of the British Isles is very wet, while the Portugal and the two French regions Pays de la Loire and Poitou-Charentes have a significant water deficit in summer. The Basque Country, Galicia and the Azores are rather warm regions that receive regular rainfall.
The length of growing period - defined as the period during the year when average temperatures are greater than or equal to 5°C and precipitation and moisture stored in the soil exceed half the potential evapotranspiration - represents more than 240 days per year in the Atlantic area.
Finally, the northern and central parts of the Atlantic area are characterized by a good grass growth that favours the use of pasture. In the southern part, conditions are often favourable for maize silage production or other fodder crops.

What are the challenges for the dairy sector in the Atlantic Area?

Agriculture must meet the food demand, which is linked to population growth, while producing in a cleaner way and maintaining fair working conditions and remuneration for farmers. Agriculture, especially the livestock sector, plays a key role in the emissions of greenhouse gas (GHG). According to the Intergovernmental Panel on Climate Change (IPCC, 2019), agriculture accounts for 23% of global GHG emissions in the world. The livestock sector accounts for 14.5% of total GHG emissions (FAO, 2013). Cattle (beef, dairy) are thought to be responsible for about two-thirds of that total (FAO, 2017). At the same time, this agricultural sector is one of those most at risk from the negative effects of climate change.
Consequently, in 2020 Europe launched the framework of the Green Deal, its agricultural strategy «From Farm to Fork» which aims to fight against climate change, protect the environment, preserve biodi-

versity, provide sustainable and affordable food, and reduce dependence on chemical fertilisers, pesticides, antibiotics...

Thus, the dairy sector in the Atlantic area must face a range of different challenges:

- Reducing production costs and improving the economic resilience of dairy farms, which are vulnerable to price volatility;
- Increasing the efficiency of resource use (water, feed, etc.) and controlling the impact of livestock farming on the environment;
- Improving the image of dairy farming to ensure the succession and new entrants to the industry;
- Improving working conditions and management, bearing in mind the size of farms is expected to increase in the future.

What is the role of the Dairy 4 Future project in this context?

From Scotland to the Azores, the Dairy 4 Future project aims to increase the competitiveness, sustainability and resilience of dairy farms in the Atlantic area. The goal was to identify, evaluate and then spread innovative practices to European dairy technicians and farmers through transnational seminars or farm open days, publications, videos or training tools.

Dairy 4 Future project focused on four key issues: analyse the strengths and weaknesses of the dairy sector in Atlantic area, foster dairy sector economic resilience, improve resource use efficiency and determine sustainable dairy systems for the future.

A network of pilots farms, known for their innovative practices in conventional or organic production, managed by motivated and committed farmers, was set up. Farms were spread over all the regions involved in the project (including 20 farms located in regions Normandy, Brittany and Pays-de-la-Loire). Data were collected, processed and analysed. Results were shared and discussed among the farmers and findings are contained in some chapters in this booklet. The goal was to highlight strong points and best practices in terms of technical and economic efficiency.

The project put innovative farmers at the center of practice-based research work and combined several methods (SWOT analysis, research activities, economic simulations, exchange visits) to adapt and develop scientific knowledge, which will lead to technical solutions and recommendations that can be shared across the network.

What were the main difficulties of the project and how were you able to solve them?

Like all professional and private activities around the world, the Dairy 4 Future project suffered from the COVID-19 health crisis, however efforts were made to maintain the link between countries, regions, partners and farmers during the confinement periods.

A proportion of trips, meetings, workshops, open days initially planned have been replaced by virtual events. This solution, which was certainly less warm and welcoming, nevertheless allowed the group to maintain the project's direction and achieve goals.

• KEY FIGURES

Dairy 4 Future project involves:

5 countries

12 Atlantic regions

11 technical partners

100 pilot farms

10 experimental farms

The Atlantic area represents:

41 million tonnes of milk

23% of the European milk production (EU28)

80,000 dairy farms

MAP 1: THE 12 REGIONS OF THE 5 COUNTRIES INVOLVED IN THE DAIRY 4 FUTURE INTERREG ATLANTIC AREA PROJECT

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TABLE 1: KEY FIGURES OF THE DAIRY SECTOR IN THE ATLANTIC AREA (2021)

Atlantic area Regions	MILK DELIVERED (MILLION T)	PART OF THE NATIONAL PRODUCTION	NB OF DAIRY COWS	NB OF DAIRY FARMS	AVERAGE COWS/FARM	AVERAGE MILK PRODUCTION/COW (KG/YEAR)	AVERAGE CONCENTRATES/COW (KG/YEAR)	STOCKING RATE (LSU/HA)
Northern Ireland	2.53	16.5%	318 372	3 252	98	8 309	2 550	2.0
Scotland	1.46	12%	176 334	832	216	8 506	3 000	2.0
Wales	2.11	13%	252 249	1 730	159	8 150	3 000	2.0
South-West England	3.69	23%	415 220	2 106	197	8 650	3 000	4.0
Rep. of Ireland	9.02	100%	1 505 000	15 320	91	5 980	1 000	2.1
Normandy	3.83	16.3%	576 150	6 727	86	6 646	1 150	1.5
Brittany	5.37	23%	693 590	9 900	72	7 969	1 000	1.5
Pays de la Loire	3.73	16%	501 164	6 900	71	7 230	1 250	1.35
Nouvelle-Aquitaine	0.97	4%	154 914	1 959	79	6 236	1 850	1.35
Basque Country	0.17	2%	20 294	470	67	8 548	2 500	3.0
Galicia	3.0	40%	336 720	6 404	53	8 875	2 200	2.0
North Portugal	0.78	39%	82 000	na	na	na	na	na
South Portugal	0.35	17%	34 000	360	284	9 630	3 400	1.0 to 4.0
Azores	0.73	33%	92 000	na	na	7 200	500 to 1 500	1.5 to 2.0

na: non available

• ESSENTIAL POINTS

- Among the major strengths of the Atlantic area, the main one is the optimum temperate climate with adequate precipitation which allows a good grass growth.
- At the farm level, the main weaknesses are systems sensitive to milk price volatility with low margins and thus difficulties in expanding the business.
- Global warming is a major threat for all regions mostly because of the dryness and drought risk during the grass growing period.
- Except for Brittany, the rest of the North Atlantic case study regions indicated an expected increase in milk volume output to 2030. All regions are projecting an increase in average dairy herd size between 2019 and 2030.

The dairy sector in the Atlantic area

HOW HAS THE DAIRY SECTOR IN THE ATLANTIC AREA PERFORMED IN RECENT YEARS? WHAT ARE ITS STRENGTHS AND WEAKNESSES, ITS OPPORTUNITIES AND THREATS? FINALLY, WHAT ARE ITS PROSPECTS FOR 2030? HERE ARE THE KEY ELEMENTS THAT WILL HELP ANSWER THESE QUESTIONS.

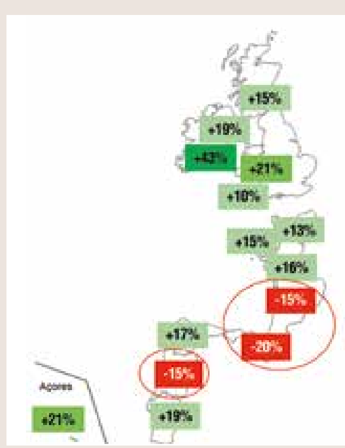
WHAT ARE THE KEY FIGURES OF THE DAIRY SECTOR IN THE ATLANTIC AREA?

Marion CASSAGNOU,
Agro-economist, Institut de l'Élevage (France)

The dairy production in the Atlantic area represents around a fifth of the UE28 production. The area benefits from an oceanic climate with high rainfall in comparison with other European regions and includes different pedoclimatic environments which allow a large diversity of dairy systems.

FIGURE 1:
EVOLUTION OF MILK PRODUCTION FROM 2007 TO 2017 IN THE REGIONS OF THE ATLANTIC AREA

Ireland has increased its milk production by over 40% between 2007 and 2017. This is by far the largest increase in the Atlantic area during his period.



Dairy production in Atlantic area: dynamic in almost all the regions

The milk production is quite dynamic with, between 2007 and 2017, an increase in volumes produced over the regions except for the 3 regions New Aquitaine, Basque Country and North Portugal (Figure 1).

Three types of dairy systems based on feed requirement and land use can be characterised. They are mainly climate and soil driven:

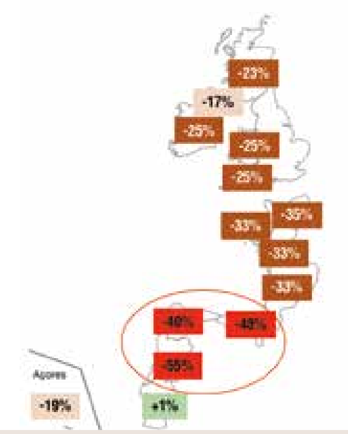
- In the western British Isles, with abundant rainfall and harder-to-plough soils, grazed and silted perennial grassland remains the base of the forage system;
- When it is possible and easy to plough, maize silage completes the feed diet, as in the western part of France;
- In north-west Spain or Portugal, the milk systems become more intensive with permanent housing and a higher quantity of concentrates.

The number of dairy farms in decline

Except in Ireland, the number of dairy cows is decreasing and the trend over the last 10 years shows that the decline in number of farms is larger in the southern regions (Figure 2).

FIGURE 2:
EVOLUTION OF NUMBER OF DAIRY FARMS FROM 2007 TO 2017 IN THE REGIONS OF THE ATLANTIC AREA

From 2007 to 2017, the number of dairy farms has dropped significantly in almost all regions of the Atlantic area, particularly in the 2 Spanish regions and in the north Portugal.



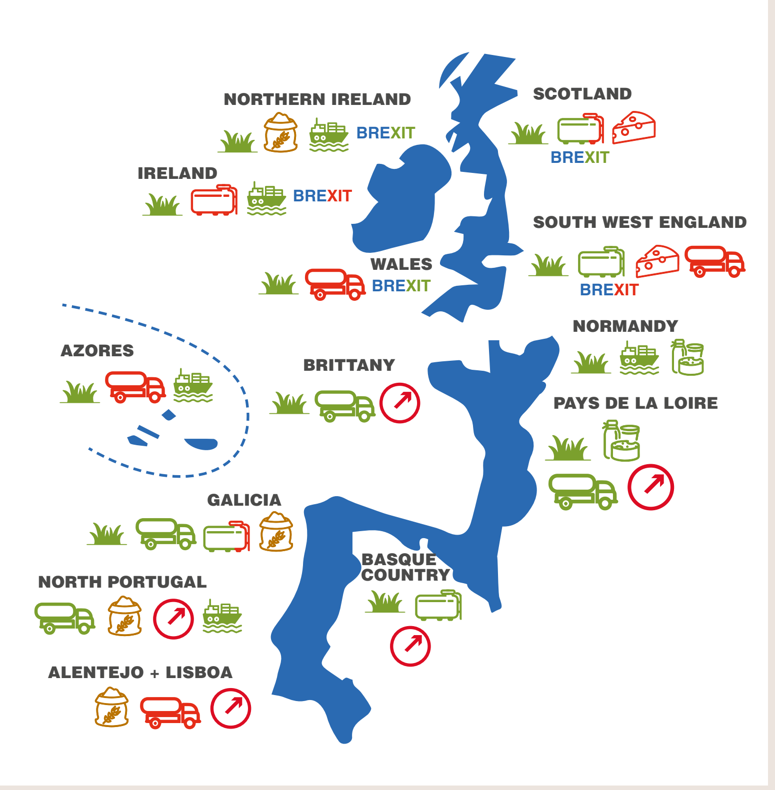
The transformation has been significant in Spain and North Portugal where herds are smaller, with less than 50 cows/farm in average.
South Portugal is an exception because the number of farms had not changed between 2007 and 2017 but they expanded from an average of 161 cows in 2007 to 284 cows in 2016.

In Portugal, there are three strategies surrounding milk production. In northern and southern Portugal, farms have become specialized in terms of land use and intensity of inputs. Restructuring has led to a sharp decline in the number of farms and those that remain today have large herds (in the north, more than a third have more than 100 cows and in the south it's around 90%). Cows are kept "indoors" during all the year and yield nearly 9000 kg/year. Conversely, in the Azores, the system is based more on grazing, with 34 cows in average in each herd.
In Galicia and the Basque Country, in this wet and temperate part of Spain, grazing has decreased in favour of the corn-rye grass association, as has been seen in Portugal. Therefore, grazing is mostly for dry cows and heifers while dairy cows are in housed in the shade. A race to raise yields has resulted in an increase in feed purchases and concentrate use. Farms have therefore become particularly sensitive to feed price volatility.
In the west of France, dairy systems are based on self-sufficiency for cows through grazing, supplemented or not by maize silage. However, milk production per hectare of grassland is lower than in Ireland and mechanization costs are also higher, making the French system less competitive than the Irish one.
Ireland is one of the few EU countries where milk expansion has not resulted in higher production costs. In Ireland, milk production is based on a grazing system thanks to a temperate climate and has increased during the last decade. Irish farmers significantly increased the size of their herd, from an average of 53 in 2008 to 91 in 2021 and have mostly moved away from beef cattle and replaced them with dairy cows.

Translating the strengths, weaknesses, opportunities and threats of the Atlantic area dairy sector

A SWOT analysis of the dairy sector has been carried out in the 12 regions of the Atlantic area. Main trends, common to almost all the regions, emerge while some points appear to be linked to few of them. The results are summarized in figure 3 and largely presented in pages 10 to 20.

FIGURE 3: MAIN RESULTS OF THE SWOT ANALYSIS OF THE DAIRY SECTOR IN THE REGIONS OF THE ATLANTIC AREA



STRENGTHS

Among the major strengths of the Atlantic area, the main one would be the optimum temperate climate with adequate precipitation which allows a good grass growth.

In most regions, there is a high density of dairy industries which achieve good efficiency of production.

Most regions are located in a consumption area and some of them benefit from the proximity of an international harbor for export (Normandy and Ireland for example).

Some of the regions are in an important milking production area and research centers or experimental farms can provide advice to farmers and assist with innovations (for example in Brittany, Ireland, Northern Ireland).

In dynamic dairy areas, recent investment at farm and processing levels had been carried out.

An important variety of products is a strength as there is less dependence on a specific market.

WEAKNESSES

At the farm level, the main weaknesses are systems sensitive to milk price volatility with low margins and thus difficulties in expanding the business.

Low availability or high prices of land discourage or stop investment. More generally, there is a rapid decline in dairy farm numbers which is more pronounced in the southern part of the Atlantic area.

For the most part, there are difficulties with succession.

Depending on the use of concentrate feed, a high dependency in the diet and cost could be a risk.

At the processing level, there are in some regions experienced logistical issues with misallocation of dairy industries or high cost of collection.

In Wales, poor road infrastructure and a lack of processing capacity were found to be weaknesses. In Scotland, some remote farmers rely heavily on a single milk processor to collect their milk. Concerning the Azores, the remoteness of the islands increases processing costs.

Some regions depend on a market, for example Wales depending on England. Other regions produce little variety of products (mostly cheese) which depends on consumption of it.

OPPORTUNITIES

The end of milk quotas in 2015 had been an opportunity for most regions to increase production or to provide confidence in investing in milk production.

Secondly, the increase of world demand for dairy products and mostly developing countries has been of benefit to the Atlantic area regions.

BREXIT Brexit is mostly an opportunity for Wales, Northern Ireland and Scotland as there is less competition from Ireland and continental Europe.

Comparing to indoor systems, grazing outside systems benefit from a better "green" image from consumer, allowing more differentiation and branding, however both suffer from an increasing influence of flexitarian and vegan diets.

THREATS

Global warming is a major threat for all regions mostly because of the dryness and drought risk during the grass growing period. The only exception could be for Scotland which could benefit from it mostly during winter.

All the systems are exposed to increases in production cost, inflation of inputs and lack of labour pool, however indoor systems are the most exposed to price volatility.

The strengthening of environmental constraints was perceived as an issue by all regions mostly because farmers fear that they may not to be supported during the transition.

BREXIT Brexit is a threat for the south-west England because it closes some markets, as for Ireland and France. All northern regions of the Atlantic area agree that Brexit makes business uncertain.

« A very green image of grazing systems in Northern Ireland and Ireland but questions about Brexit. »

NORTHERN IRELAND: dairy sector SWOT analysis

STRENGTHS

- Temperate climate with adequate precipitation.
- Grass based milk production system.
- Relative farm size and specialization.
- Work ethic of dairy farmers.
- Efficiency of production.

WEAKNESSES

- Increasing confinement of dairy cows.
- Concentrate feed use level.
- Educational attainment of farmers.
- Commodity nature of dairy product mix.
- Processor scale of operation.

OPPORTUNITIES

- Increasing world demand for dairy products.
- Positive image of Ireland – the Origin Green link.
- Brexit, access to the UK dairy market.
- Emerging research on dairy health benefits.
- Developing animal sensor technology.
- Automated milking technology.

THREATS

- Brexit – business uncertainty.
- Air quality legislation.
- Water quality legislation.
- Antimicrobial product use.
- Age profile of dairy farmers.
- Farm labour supply.
- Veganism.

IRELAND: dairy sector SWOT analysis

STRENGTHS

- Low-cost grass based system of production.
- Low carbon footprint of milk production with high sustainable credentials.
- Reputation for world class food safety standards.
- Access to 130 export destinations - A sophisticated dairy industry with a number of indigenous players with global reach.
- High levels of recent investment at processing and farm level.
- World class research capability.

WEAKNESSES

- High land rent and labour costs.
- Vulnerable to milk price shocks.
- Comparative lack of scale at processing level.
- Commodity product mix.
- Seasonality of production.
- Skills availability.
- Low rate of land mobility.
- Transport costs to market.

OPPORTUNITIES

- Production expansion with end of milk quotas.
- Capacity to increase productivity as size of the average farm increases.
- Scope to move up value chain with focus on more business to consumer, ingredients and nutrition products.
- Increased importance of third country markets (China, Africa, Gulf, US).
- Green sustainable systems allowing for differentiation and branding.

THREATS

- Failure to achieve greenhouse gas emission reduction targets.
- Failure to maintain or improve water quality and biodiversity outcomes as per EU Directives – Loss of Nitrates Derogation.
- Brexit – Heavy reliance on the UK market.
- Extreme price volatility.
- Animal disease outbreak.
- Food safety incident.
- Raw material supply.

> « In Scotland, the low consumption of milk and the limited processing capacities lead to milk exports to England for transformation. »

SCOTLAND: dairy sector SWOT analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• High density of production and processing in certain areas. • Many jobs in the industry. • Good grass growing regions in the south-west. • Strong milk processors in the region, including the 2 largest in the UK (Arla and Muller). • Good mix of co-ops, DPO and private-owned processors giving competition for milk. • Large average farm size.	• High reliability on cheese, and in particular cheddar production compared with rest of the UK. • "Exporting" surplus milk to England for processing – and therefore incurring processing costs. • Some remote farmers highly reliant on just one milk processor to collect their milk. • Weather conditions can be harsh, particularly further north, but also late arrival of spring.	• Import displacement for home-grown products such as cheddar, cottage cheese and yoghurt. • Global warming could improve grazing conditions and forage growing opportunities in some regions. • Brexit potential to encourage other sectors (e.g. lamb) to switch to dairy. • A number of large, proactive farmers operate in the region and have grown rapidly in recent years – further growth could bring benefits.	• Domestic consumption is low compared with milk and product production, therefore highly reliant on exports out of the region. • Contestation of the food and health quality of milk. Increasing influence of flexitarian movements and vegans. • Climate change could lead to more severe weather conditions in certain regions. • Strengthening environmental constraints. • Growth in production costs (energy, inputs, labour). • Lack of labour pool post Brexit. • Lack of support post Brexit.

« In Wales, two-thirds of dairy farms (gathering 56% of the cows) graze their herds for between 183 and 273 days per year. »


©DR

WALES: dairy sector SWOT analysis

STRENGTHS

- Grass based production.
- All year calving pattern.
- Good image.
- Temperate climate.
- Large market on doorstep.
- Reasonable skills set.
- Good scale on some farms.
- Traditional farms.
- Dense milk fields south-west and north.
- Young Farmers' Clubs very strong.

WEAKNESSES

- Knowledge to exploit grass could be improved.
- Dairy farmers have little control over price.
- Poor road infrastructure.
- Lack of processing capacity.
- Milk sold as a loss leader.
- Fallen behind on innovation.
- Upskilling of farm staff.
- Transport infrastructure.
- Small population cannot support dairy industry alone.
- Dependent on English market.
- Range in farm production efficiencies.
- Range in farm knowledge of how market works.
- Few options for contracts.

OPPORTUNITIES

- Fantastic location for milk production and processing investment.
- Competitive raw material and efficient processing.
- Increasing world demand.
- Industry can grow.
- Development of Welsh brand.
- Feasibility study for milk processing in South Wales.
- Direct Rural Development Programme funding based on outcomes.
- Encourage innovation.
- Identify the right people to lead the industry.
- Education of farmers on markets, trends and forecasts.
- Room for some seasonal milk supply.
- Development of discussion groups.
- Export market.
- Development of Protected Designation of Origins, Protected Geographical Indications and food tourism.
- Brexit.

THREATS

- Failure of a major milk buyer could have a big impact.
- Costs to access English market.
- Failure to tackle biosecurity and animal disease (Johnes', Tuberculosis, Bovine Viral Diarrhoea, etc).
- Disease management.
- Price volatility.
- Extreme weather events.
- Rising input costs.
- Lack of skilled staff.
- South Wales could become a "buffer" for UK milk production requirements.
- Challenge of moving niche to large scale – small manufacturers find it difficult to expand.
- South West Welsh milk only needed when it suits.
- Poor market understanding could lead to bad investment decisions.
- Brexit.

« Many small processors operate in South West England and play an important role in the rural economy of the region. »

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SOUTH WEST ENGLAND: dairy sector SWOT analysis

STRENGTHS

- High production potential related to good grass growing potential.
- Many jobs in the industry and significant expertise in ancillary industries (animal nutrition and health, agronomy,..).
- Knowledge Exchange and educational centres specialising in dairying e.g. Duchy College.
- Strong milk processors in the region, including the 2 largest in the UK (Arla and Muller) and the biggest branded cheddar producer (Dairy Crest).
- Good mix of co-ops, DPO and private-owned processors giving competition for milk.
- High reliability on cheese, and in particular cheddar production compared with rest of the United Kingdom.
- Good range of products with special characteristics, included a PDO product, which makes them attractive for the international market.
- Wide ranging production systems, high input/high output throug to extended grazing. Opportunities to adapt as necessary.

WEAKNESSES

- High reliability on cheese, and in particular cheddar production compared with rest of the United Kingdom.
- There is more milk produced in the south of the region than is processed in that region, although announced investments will help rebalance this.
- Transport routes can get jammed up in summer seasons due to holiday traffic and can be hazardous in snow and icy conditions in winter; also, a number of roads (hilly terrain) are difficult to navigate with milk tankers.
- No motorway East of Exeter.
- Distance from main centres of population.
- Environmental risks: with rapid rise in herd size, investment in slurry storage and processing has not kept in line with investment in cow accommodation and milking facilities.

OPPORTUNITIES

- Brexit potential to encourage other sectors (e.g. lamb) to switch to dairy.
- A number of large, proactive farmers operate in the region and have grown rapidly in recent years – further growth could bring benefits.
- Processors have been willing to invest in the region (e.g. Dairy Crest increase capacity by c200m litres per year).
- Impact of planned purchase of Dairy Crest by Saputo.
- Direct sales or adding value for home tourism market (Cornwall had highest ever tourist numbers in 2018). The far South West is a major internal tourist destination (perhaps more so post-Brexit).
- Growing interest in agricultural production systems and organic products due to concerns about climate change and biodiversity loss (SW has a large number of organic farms, and potential due to Omsco's location in Weston-Super-Mare).

THREATS

- Questioning of the food and health quality of milk. Increasing influence of flexitarian movements and vegans on health concerns, welfare concerns and climate change concerns.
- Climate change could lead to more severe weather conditions in certain regions, with higher severity and uncertainty of weather conditions (wetter summers which would impact on grazing and forage conservation).
- Strengthening environ-mental constraints.
- Growth in production costs (energy, inputs, labour possibly lacking after Brexit).
- Brexit impact on export markets, especially cheese, and import competition.
- Lack of labour pool post Brexit.
- Lack of support post Brexit both in direct subsidy to farmers and grants to milk processors for additional facilities.
- Impact of planned purchase of Dairy Crest by Saputo.

« In Normandy, many protected designation of origin dairy products but an increasing competition with cash crops. »

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NORMANDY: dairy sector SWOT analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• Pedoclimatic conditions conducive to the meadow and to corn-silage (regular rain, mild climate). • Dynamism of the production for 10 years («dairy atmosphere»). • Strong presence of the successful mixed-farming and breeding system. • 90% of lands in farm rent (= fewer mobilized capital). • High density of dairy delivery by km² (moderate costs of collection). • Sufficient size of the dairy region to have all the services (veterinarians, food manufacturers, counseling) and a milk collection everywhere. • Presence of 6 Protected Designation of Origin certified products (4 cheeses, 1 butter, 1 cream). • Proximity to the Port of Le Havre (1st harbour for French containers). • Presence of large, international dairy companies (including the largest Lactalis).	• Fast drop of the number of dairy farms (-4% per year). • Dairy farming is strongly declining in certain areas of low density in the east of the region. • Low incomes of the farms (identical to the French average). • Proportion of organic collection lower than that of the whole France. • In certain areas, a shortage of internal competition among dairies. • Important proportion of milk transformed by dairies with private funds, whose head offices are not in Normandy.	• Dairy products from Normandy are widely recognized among consumers. • Proximity to the Paris-London-Brussels pool of consumers. • Customs protection of the EU in relation to imports coming from the world market. • Presence of the Norman dairies in exports on the world market (China, USA, Canada, Japan).	• Reduction of subsidies from the 2015-2019 CAP (Common Agricultural Polict) for Norman dairy farms (-20% on average). • Dairy breeding faces competition from the cultures of sale in almost all the areas. • Strong intra-European competition since the end of the quotas (Ireland, Poland, The Netherlands,..). • Reduction of the consumption of soft cheeses and raw milk cheeses.

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BRITTANY: dairy sector SWOT analysis

STRENGTHS

- Favourable climate for fodder production.
- Strong density of farms, industries, education and research organisations.
- Recent investments both on farm and in the industry.
- Wide range of processed dairy products.
- Presence in Brittany of numerous players of the food processing industry (bakery and pastry, ready meals) using dairy ingredients.

WEAKNESSES

- Low economic efficiency due to high fixed costs, limited degree of farm specialization and land dispersion (fragmented and dispersed plots of land).
- Antagonistic relationships within the supply chain and highly concentrated French food retail sector.
- Value of dairy products still below French average.
- Breton exports focused on few countries.
- High volatility of milk and input prices.

OPPORTUNITIES

- Growing demand of local products and differentiated dairy products.
- Increasing world demand for butter and cheese.
- Innovation and export capacity.
- Restructuration opportunities due to the decrease in farm numbers.

THREATS

- Ageing of the farm population.
- Difficulties to find on-farm employees and competition with other productions less labour-demanding.
- Risk of cessations of activity due to negative cash flow.
- Reduction of CAP subsidies.
- Growing environmental and climate concerns.

« A discreet presence of dairy products under official quality signs but a good position in organic milk in the Pays de la Loire region. »


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PAYS DE LA LOIRE: dairy sector SWOT analysis

STRENGTHS

- High density of production and processing.
- Many jobs in the industry.
- Good soil potential – climate.
- Complementarity crops – livestock.
- Numerous recent investments in farms and processing companies.
- Differentiated products with good added value (cheeses, infant powders) and strong brands.
- Dynamism of organic dairy production.
- Products that are exported.
- Environmental assets.
- Reasonable cost of land compared to Northern Europe.
- Quality port and road infrastructures.
- Growing collective organization of producers.

WEAKNESSES

- Unbalanced relations within the sector (low weight of POs in the face of large groups).
- Dependence on CAP aid, the level of which drops for the most intensive systems.
- Few products under official quality signs.
- Aging assets.
- Some farms weakened by recent investments.
- Less attractive production with lower profitability.
- Protein dependence of the farms.
- Increasing capital needs.

OPPORTUNITIES

- Significant and diversified national consumption (segmentation), even though it is now stabilized.
- Growing global demand for a heavy trend towards value-added products.
- New valuations of dairy products (non-food).
- New potential opportunities with bilateral agreements being negotiated?

THREATS

- Slowing economic growth in emerging countries and global demand.
- Increasing intra-European competition, with risks of distortion if renationalisation of the CAP.
- Risks of increased imports if bilateral agreement with Oceania / USA.
- Contestation of the food and health quality of milk. Increasing influence of flexitarian movements and vegans ...
- Increasing climatic and sanitary hazards.
- Commercial and diplomatic tensions at the international level.
- Strengthening environmental constraints.
- Growth in production costs (energy, inputs, labor).
- Pressure on oilcake supply if reduced support for French biodiesel.


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BASQUE COUNTRY: dairy sector SWOT analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• Farms with fodder area available. • Climate: warm and rainy. • Important dairy industry. • Important network of stakeholders aiming to improve system resilience.	• Generational renewal. • Land cost. • Life quality. • Difficult to start new business. • Low margins.	• Quota abolition. • Increasing interest in organic products and grazing management. • Consumer's preference for local products. • Young generations ready to change.	• Consumer's perception. • Difficulties to face changes.

« Although milk is the main production of Galician agriculture, dairy farms, which use only 8% of the regional surface, are in tough competition with the Eucalyptus afforestation. »


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GALICIA: dairy sector SWOT analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• Favourable agro-climatic conditions for fodder production. • High density of farms in producing areas, that reduces collection costs and allows competitive services to farms. • Consolidated leadership in milk production in Spain. • Good image of product quality in the Spanish market.	• Limitations on the territorial base of farms. • Production too depending on concentrate feed. • Reduced processing capacity over the produced milk. • Absence of polyvalent industrial groups. • Low degree of industrial integration. • Weakness in the organization of the chain. • Low level of participation of farmers in the processing of their production.	• Potential to increase forage area of farms. • Deficit position of Spain as the relevant market. • Availability of milk as an incentive for the installation of new dairy processing facilities. • Expansion options on differentiated types of cheese.	• Competence of the Eucalyptus afforestation in the enlargement of the forage area of farms. • Risk of relocation of milk production in Spain towards the areas of concentration of the dairy industry and consumption. • Absence of instruments for managing short-term or structural milk surpluses due to weak organisation and low processing capacity. • Downward pressure on milk prices and risks of abandonment of milk collection by some companies. • Succession problems in a substantial part of dairy farms.

NORTH PORTUGAL: dairy sector SWOT analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• High forage yielding potential of the region. • Specialized farms and technical capacity of farmers. • Strong cooperative system given good support to dairy farmers. • Farmers open to technological innovation.	• Size and structure of farms. • Financial difficulties due to past investments. • High production costs – energy, concentrate feeding. • Location in areas with high population density - high land price and tight environmental legislation.	• Increasing exports and strengthening the internationalization of the industry. • Diversification into innovative dairy products with higher added value for external and internal markets. • Opportunity for farmers to create their own brands.	• Peripheral status of Portugal relatively to major markets. • Heavy dependence on prices of concentrate feed. • Market incertitude (milk prices and demand). • Effects of climate changes. • Society perception about dairy production (animal welfare and environmental issues like carbon neutrality).

SOUTH PORTUGAL: dairy sector SWOT analysis

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• Large farms. • Qualified farmers with strong technical support. • Proximity of feed suppliers and consumers. • Mixed farms, combining livestock and agricultural production.	• Climatic conditions, with very dry and hot summers, occasionally subjected to long periods of drought, compromising self sustainability in fodder production. • Especially in the Alentejo region, animals are subject to heat stress during summer months. • Soil conditions, with low organic matter content, very prone to erosion, with an agricultural production dependent on mineral fertilization. • Low density of dairy farms, which makes difficult the organization of the sector. • Competition with other activities for soil use. • Larger dairy processing plants located in different regions (far from farms = transport costs).	• The increase in the irrigated area due to the construction of the Alqueva reservoir, allowing the increase in fodder production. • Potential to decrease dependency from concentrate feed. • Increase in dairy products consumption at the national level (butter, yoghurts and cheese, increase at an annual average rate of 3%, 6.2%, and 3.2%, respectively). • Local farms need organic amendments to improve soil quality, which can be provided by the slurry and manures produced by the dairy farms. • Interest of foreign dairyfarmers (e.g., Dutch nationals).	• Reduction of milk price. • Growth in production costs (feed, energy, labour). • Competition from other dairy regions in Portugal and EU. • Decrease in liquid milk consumption at the national level (since 2001, at an annual average rate of -2.4%), as well as in other markets, associated to a pejorative idea of the food and health quality of milk. • End of milk quota regime (April 2015) and the EU implementing measures in order to control excess production and to promote their reduction. • Environmental constraints, with some movements associating livestock production to GHG emissions.

« In South Portugal, climatic conditions, with very dry and hot summers, accasionally subjected to long periods of drought, compromise self sustainability in fodder production and reduce the grazing period. Especially in the Alentejo region, cows are subject to heat stress during summer months. »

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« In the Azores, the dairy production is very dependant on pasture, with more than 90% of grassland in fodder area. »

THE AZORES: dairy sector SWOT analysis

STRENGTHS

- Milk sector increase for the decade 2007-2017, based on a significant increase of productivity per cow.
- Association of the milk sector to the tourism in Azores, which is increasing (one of the most characteristic images of Azores is the cows grazing).
- Good soil and climate conditions for pasture and fodder production, which allows a good milk quality.
- Good acceptance of the consumers to the Azores dairy products due to "green image" ("Happy cows" program from Bel helped to improve that image).
- Traditional and main agricultural activity.

WEAKNESSES

- Insularity, which increases transportation costs to and from the continent (e.g., feed, milk).
- Geographical isolation, especially for some islands/ parts of some islands, which limits the technical support to the farms and dairy plants, and the introduction of technological improvements.
- Poor sector organization (too many actors).
- Small size of the farms, frequently divided in non-contiguous plots of land, small size of the herds, and high number of farms.
- Lack of alternative to dairy farming.

OPPORTUNITIES

- Increase in dairy products consumption at the national level (butter, yoghurts and cheese, increase at an annual average rate of 3%, 6.2%, and 3.2%, respectively).
- Markets growing interest in differentiated milk (e.g., pasture milk, organic), which has a great potential to be produced in the Azores region.
- Farmers motivated to improve production.
- Close connections with USA and South America.
- Increase of tourism which can improve products promotion.

THREATS

- Strong economic support (subsidies), making the economic sustainability of the sector very much dependent on those subsidies.
- Decrease in milk consumption at the national level (since 2001, at an annual average rate of -2.4%), as well as in other markets, associated to a pejorative idea of the food and health quality of milk.
- End of milk quota regime (April 2015) and the EU implementing measures in order to control excess production and to promote their reduction.
- Environmental constraints, with some movements associating livestock production to greenhouse gas emissions.
- Reduction of milk price.
- Growth in production costs (feed, energy, labour).
- Intensification of the dairy production (decrease of grazing period).

PROSPECT FOR MILK GROWTH AND DAIRY FARM STRUCTURES TO 2030

Cathal BUCKLEY,
Research officer, Teagasc (Ireland)

Over the past few decades, European dairy production has known a strong restructuration in most of the countries (and it was even stronger among the new members from Central and Eastern Europe where subsistence-oriented farming remains a reality of rural areas). That transformation is characterized by a reduction of the number of dairy farms, and in parallel, an increase of the production on the farms that have maintained the dairy activity.
But what are the prospects for the dairy sector in the Atlantic area up to 2030? The main trends are presented here and come from survey carried out among the Dairy 4 Future project partners.

Milk output growth, an uncertain future for Brittany

Except for Brittany (which is projecting to a volume decline of circa 5%), the rest of the North Atlantic case study regions indicated an expected increase in milk volume output to 2030. Except for the Basque Country (2%) and the Republic of Ireland (21%), the other regions indicated an increase of between 9-15% as outlined in Figure 4.

More dairy cows in Ireland and a decline in Brittany and Galicia

In terms of the dairy cow population, this showed greater levels of expected variability around the North Atlantic case study regions. Galicia, Brittany, south-west England and the Basque Country indicated a decline in the dairy cow population of between -3% to -13%. Whereas Wales (3%), Scotland (10%) and the Republic of Ireland (17%) indicated projected increase in overall dairy cow numbers as illustrated by Figure 5.

Fewer farmers but larger farms

A consistent trend across the North Atlantic regions was a decline in the dairy farmer population and an increase in the size of the average dairy farm. Galicia was projected to have the largest percentage decline in dairy farm numbers (-49%) followed by south-west England (-37%), Brittany (-32%), Wales (-30%) and Scotland (-24%). Northern Ireland (-15%) and the Republic of Ireland / Basque Country (-10%) were expected to experience a more moderate decline (Figure 6).

FIGURE 4: PROJECTED MILK VOLUME OUTPUT GROWTH BY NORTH ATLANTIC REGION FROM 2019 TO 2030

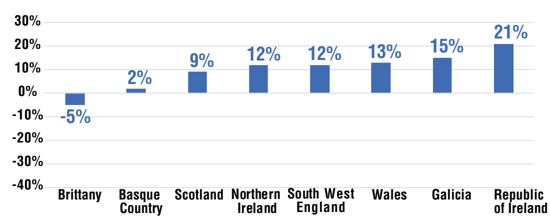


FIGURE 5: PROJECTED DAIRY COW POPULATION CHANGES BY NORTH ATLANTIC REGION FROM 2019 TO 2030

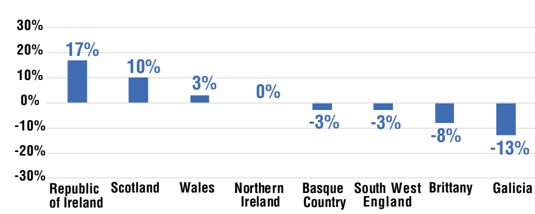
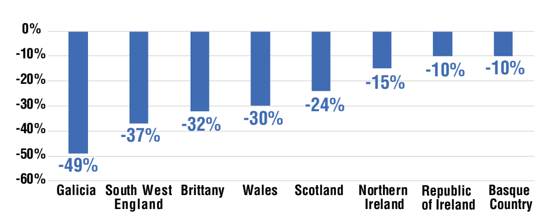


FIGURE 6: PROJECTED DAIRY FARMER POPULATION CHANGES FROM 2019 TO 2030



• BENCHMARKS

Until April 2015, when the quota regime was still in place, European dairy farms used to expand their production by acquiring milk quota volumes released by those ceasing the activity. In the 2nd half of the 2000s, a lifting of the quota regime led to a grow up of European milk production.

The 28 countries that used to constitute European Union between 2013 and 2020 have seen their cumulated production growing up from a few 150 million tonnes at the beginning of the 2000s (among which 134 MT were delivered to dairies) to around 170 million tonnes (160 MT delivered to dairies).

FIGURE 7: PROJECTED AVERAGE FARM SIZE INCREASE BY NORTH ATLANTIC REGION FROM 2019 TO 2030

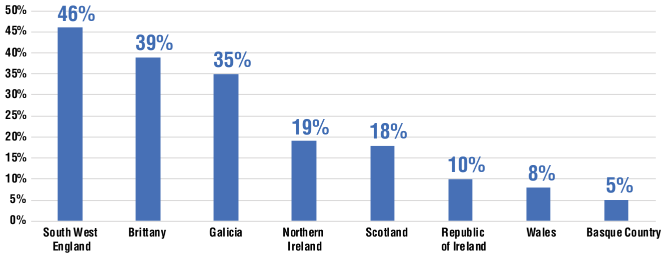


FIGURE 8: PROJECTED DAIRY HERD SIZE CHANGES BY NORTH ATLANTIC REGION FROM 2019 TO 2030

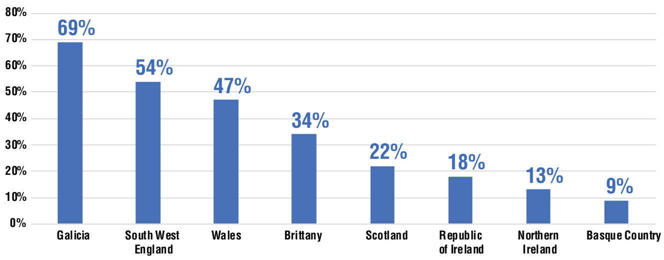


FIGURE 9: AVERAGE CHANGE IN MILK YIELD (VOLUME AND MILK SOLIDS) BY NORTH ATLANTIC REGION FROM 2019 TO 2030

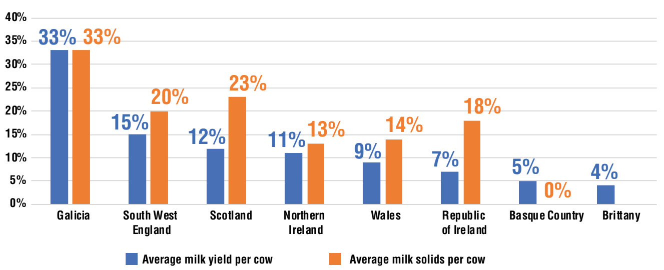
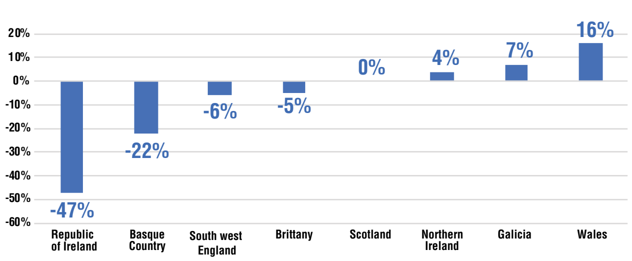


FIGURE 10: PROJECTED CHANGE IN CONCENTRATE USE BY NORTH ATLANTIC REGION FROM 2019 TO 2030



With the projected decline in dairy farm numbers, it follows that the average farm size of those remaining is likely to grow. The three North Atlantic case study regions (south-west England, Brittany and Galicia) that projected the largest decline in dairy farm numbers is expected to see the largest increase in average farm size to 2030 (35% to 46%). Northern Ireland and Scotland expected similar levels of average farm size increase (18-19%), followed by the Republic of Ireland (10%), Wales (8%) and the Basque Country (5%) as seen in Figure 7.

All regions are projecting an increase in average dairy herd size between 2019 and 2030. However, the extent of the increased varies significantly. Galicia is expecting the largest percentage increase (69%) followed by south-west England (54%), Wales (47%) and Brittany (34%). This was followed by Scotland and the Republic of Ireland (18-22%), Northern Ireland (13%) and the Basque Country (9%) as outlined in Figure 8.

More milk per cow, but with regional differences

It is projected that average milk yield per cow (in volume terms) would increase across all North Atlantic study regions. Galicia projected the largest estimated increase at 33%. This was followed by south-west England (15%), Scotland (12%), Northern Ireland (11%), Wales (9%) and the Republic of Ireland (7%). The Basque Country and Brittany indicated an average yield increase of 4-5% over the 2019 to 2030 period as indicated by Figure 9.

However, some regions indicated that milk solids output per cow would increase at a faster rate (Figure 9). Galicia again indicated a 33% increase, followed by Scotland (23%), south-west England (20%) and the Republic of Ireland (18%). Wales and Northern Ireland indicated milk solid per cow increases of 13-14%.

More milk per cow… with less concentrate!

As shown by figure 10, concentrate use associated with milk production is expected to increase in Wales (+16%), Galicia (+7%) and Northern Ireland (+4%), while concentrate use in Scotland is projected to remain stable. Decreases are projected in south-west England (-6%) and Brittany (-5%) and more dramatically in the Basque Country (-22%) and the Republic of Ireland (-47%).

Projected fertiliser use on dairy farms: less dependence

Except for south-west England (+3%), it was projected that milk would be produced with reduced quantities of chemical nitrogen fertiliser inputs across the case study regions (Figure 11). This ranged from -33% for Basque Country, -10 to -15% for Scotland Northern / Republic of Ireland to -6% and -5% for Wales and Brittany. Galicia projected remaining at current levels.

Risk factors that could constrain future milk production

A number of potential risk factors were identified that could constrain the milk production output to 2030. These were identified in each region and were classified as either low, medium or high risk factors (Table 2).

- **Greenhouse gas emissions** (GHG) were identified as a high risk potential constraint to future milk production in 3 regions (Republic of Ireland, Northern Ireland and Scotland) and as a medium risk factor in 3 other regions (Wales, south-west England and the Basque Country).
- **Access to land** for milk production was also identified as a high risk factor by 3 regions (Republic of Ireland, Northern Ireland and south-west England) with a further 2 classifying it as a medium risk factor (Wales and Scotland).
- **Future processing capacity** is another issue identified by 3 regions (Republic of Ireland, Northern Ireland and Wales) as a high risk factor.
- Two regions (Republic of Ireland, Northern Ireland) identified **biodiversity loss** as a high risk factor.
- Two other regions (Scotland & Wales) identified **shortage of labour** as high risk.
- One region (Scotland) identified **future trade agreements** as a high risk factor.
- One region (south-west England) highlighted **replacing CAP funding post Brexit** as a high risk factor.

Greenhouse gas emissions and access to land were identified as high risk potential constraints to future milk production in the Atlantic area.

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FIGURE 11: PROJECTED CHANGE IN CHEMICAL N USE BY NORTH ATLANTIC REGION FROM 2019 TO 2030

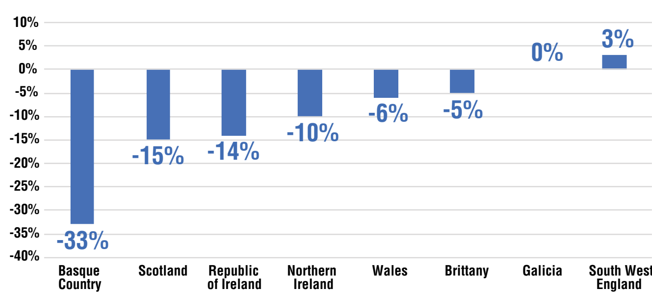


TABLE 2: RISK FACTORS THAT COULD POTENTIALLY CONSTRAIN FUTURE MILK PRODUCTION DAIRY AND OUTPUT SELF-SUFFICIENCY BY NORTH ATLANTIC REGION FROM 2019 TO 2030

Risk factors	REP. OF IRELAND	NORTHERN IRELAND	WALES	SCOTLAND	SOUTH WEST ENGLAND	BASQUE COUNTRY	BRITTANY
Environment: greenhouse gas emission	Red	Red	Yellow	Red	Yellow	Yellow	Red
Processing capacity	Red	Red	Red		Yellow		
Access to land	Red	Red	Yellow	Yellow	Red		Red
Environment: water quality	Red	Red	Yellow	Yellow	Yellow	Yellow	Red
Environment: biodiversity	Red	Red		Yellow	Yellow	Yellow	
Access to labour	Yellow	Yellow	Yellow	Red	Red		Red
International trade agreements	Yellow	Yellow	Yellow	Red	Yellow		Yellow
Changing Ag policy (replacing CAP)			Yellow		Red		
Brexit	Yellow	Yellow					
Lack of succession plan				Yellow			Yellow
Tenancy				Yellow			
Gross margin (contracts)				Yellow			

FARMERS' POINT OF VIEW ABOUT THE ECONOMIC SUCCESS OF DAIRY FARMS: WHAT ARE THE ISSUES FOR FARMERS IN THE ATLANTIC AREA?

Aubin LEBRUN,
Technical Manager System Strategy and Livestock Economics, Institut de l'Élevage (France)

64%
of surveyed farmers consider that the nature of their dairy contract is favourable to their activity

For more than
70%
of the surveyed farmers, the price of agricultural equipment and the difficulties of access to land have a strong impact, to the detriment of milk production

Dairy farm profitability is considerably affected by external factors (decisions/ events which appear independently from the farmer). Therefore, economic resilience of dairy farms will depend on external relationships issues and how farmers are dealing with stakeholders.

An online survey, addressed to the farmers involved in Dairy 4 Future project, was carried out in spring 2020. A total of 34 Portuguese, 17 French, 16 Spanish, 11 Irish and 11 UK dairy farmers were surveyed. Answers allowed to assess the depth and diversity of economic stakeholders (dairies, suppliers, banks, etc.) present in the respondents' regions, and to identify the external factors considered as beneficial or unfavorable to the economic success, according to the farmers.

Type of dairy contract: the key to economic success for Irish and UK farmers

For the most of surveyed farmers (64%), the type of dairy contract they have is favorable to their business (Figure 12). Several parameters that differ between countries and dairy operators must be considered when interpreting this result: the limited production volume, the price fixing mechanism, the period of commitment, etc. For example, all the Irish farmers surveyed and ¾ of the UK farmers stated that they had no restrictions on the volume of milk they could produce.

The answers also show disparities in the way prices are set. In Ireland and the United Kingdom, contracts with guaranteed milk prices or covering production costs are largely developed, while in France, Spain and Portugal, they are still difficult to be deployed.

Bank loans: more or less favorable access conditions depending on the country

The decrease in bank interest rates is a favourable context for investments. The results of the survey show that 61% of dairy farmers consider that the access to credit is favourable to their business (Figure 13).

FIGURE 12: EFFECT OF THE TYPE OF DAIRY CONTRACT ON THE ECONOMIC SUCCESS OF THE SURVEYED FARMERS

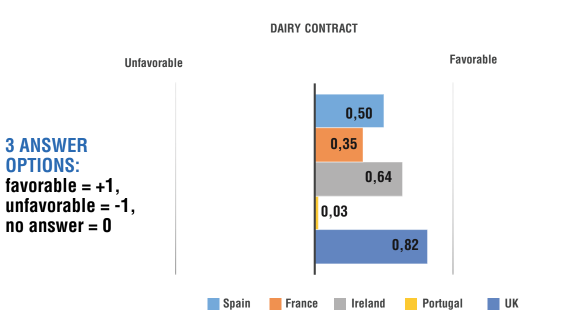
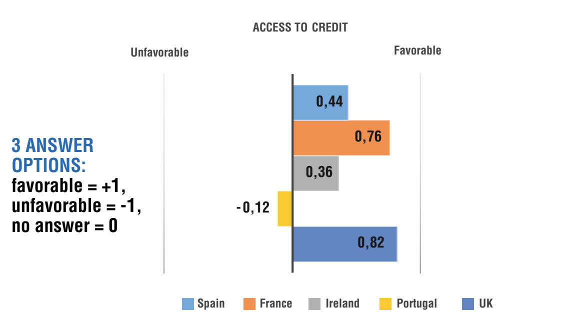


FIGURE 13: EFFECT OF CREDIT ACCESS CONDITIONS ON THE ECONOMIC SUCCESS OF THE SURVEYED FARMERS



When asked about the qualifications of their bank advisor, French, Irish and UK farmers state that their bank advisor is at least specialized in the agricultural sector (or even dairy).
In contrast, for ¾ of the Portuguese dairy farmers, the bank advisors are non-specialized. This result suggests a contrasting level of attractiveness of the dairy sector for banking organizations from one region to another.

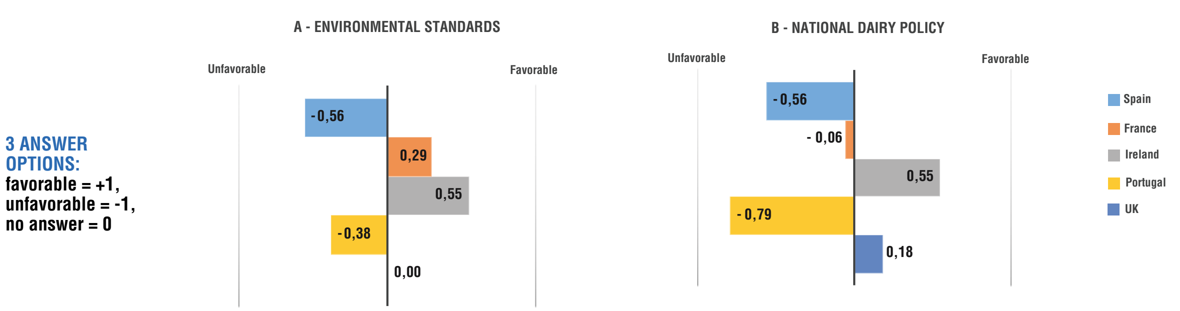
High environmental constraints and lack of political support according to Spanish and Portuguese farmers

Only one out of 8 Spanish farmers considered that the current environmental standards are favorable to their business, compared to 75% of the surveyed Irish farmers (Figure 14 – A). These contrasting results reflect the diversity of dairy systems and levels of intensification along the Atlantic area. In Galicia and the Spanish Basque Country, the large surplus of slurry is difficult to spread locally (few areas under cultivation) and it affects the profitability of farms (transport of effluents to other regions, investment in treatment infrastructures, etc.). The farmers' responses also show a variable application of European legislative measures. Ireland and United Kingdom have a derogation from the ceiling of organic nitrogen that can be spread in vulnerable zones (170 kg N/ha), as defined in the Water Framework Directive.

As with environmental standards, there is a strong contrast in terms of the national policy's effect on the economic success of farmers, depending on the country of origin (Figure 14 – B). These results highlight very different national policy strategies since the end of quotas in 2015. Ireland, which has increased its national production by more than 40% in 10 years, has set up national strategy to support this expansion: establishment of training programs, creation of a health management organization, investments in dairy industries, etc. A situation at the complete opposite of Portugal and especially the Azores, where all the surveyed farmers say that the national policy was not favourable to them and they were disappointed with the lack of basic infrastructures (milking parlour, refrigerated tank, etc.).

« The environmental issues are mainly seen as constraints for Spanish and Potuguese farmers. »

FIGURE 14: EFFECT OF ENVIRONMENTAL STANDARDS AND NATIONAL DAIRY POLICY ON THE ECONOMIC SUCCESS OF THE SURVEYED FARMERS



« Dairy farmers in the Atlantic Area are working in an increasingly complex and dynamic environment. They must constantly adapt their practices to cope with these uncontrollable external factors. They also face common obstacles such as the low availability of workforce and the lack of recognition of their profession by society. »

Access to the land, agricultural equipment prices, workforce availability, perception of public dairy farming: challenges faced by all livestock farmers

Access to the land is considered as an unfavourable factor for the economic success of dairy farms for 76% of the surveyed farmers. This result is closely linked to the price of land in the regions studied. In Spain, Ireland and the United Kingdom, the price of agricultural land cost between 20 000 and 30 000 euros per hectare. In the Azores, with one third of the Portuguese milk production is achieved, the cost of land reaches more than 40 000 euros per ha and the majority of the farmers are renting land.

Despite an encouraging banking context for investments, the majority of the surveyed farmers also underline the high price of agricultural equipment (material, installations and buildings) which weakens the economic health of the farms.

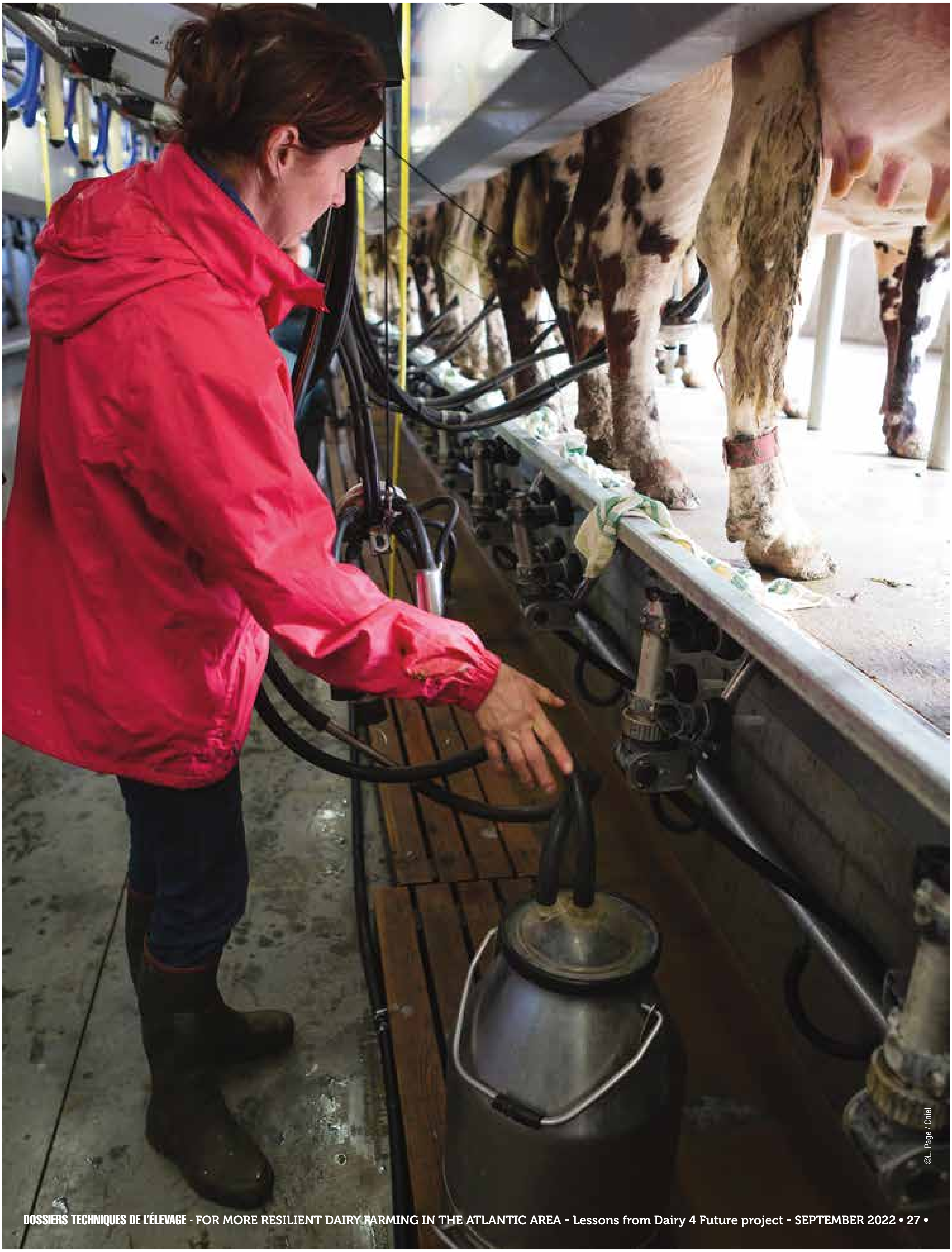
Finally, farmers testify to the lack of recognition of their profession by the rest of society. The negative externalities of dairy farming are widely decried in the media, while the rendered services are poorly highlighted. This negative perception of dairy farming has serious consequences according to the farmers: lack of workforce, decrease of attractiveness of the profession, evolution in the demand for dairy products, etc.

Dairy sectors that are organizing to support farmers

In response to the challenges faced by farmers, initiatives have been taken by sector stakeholders to improve the resilience of dairy farms. These are mainly solutions related to the nature of the dairy contract, for example by ensuring stability in the milk price paid to farmers or by remunerating practices that meet consumers' expectations: increasing grazing time, GMO-free feed, improving animal welfare and biodiversity, etc.

Regarding the financing of dairy investments, several original tools are being developed. In Ireland, for example, the development of flexible loans specific to dairy farming (e.g. MilkFlex) facilitates access to credit by adjusting repayment terms according to changes in the milk price.

Finally, research and development organizations also support farmers by helping them to make the transition to practices in line with societal expectations and/or regulations, and by enhancing the attractiveness of dairy farming to overcome the lack of workforce.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Rendered services by dairy farming, a road for added value?

• ESSENTIAL POINTS

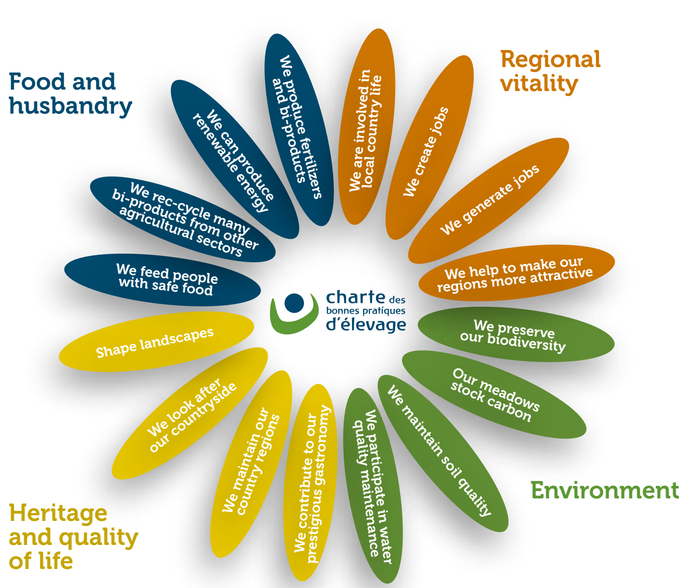
- Dairy farming generates negative impacts but also provides many services: provisioning (e.g., food), rural vitality, environmental quality and cultural heritage and quality of life.
- Several factors had been identified as helpful or harmful factors in improving sustainability of the dairy sector in the territories.
- In all the regions of the Atlantic area, initiatives are developed in order to give added value to milk production.

IF DAIRY FARMING GENERATES NEGATIVE IMPACTS ON THE ENVIRONMENT, IT ALSO PROVIDES MANY SERVICES: SUPPLY OF ANIMAL PRODUCTS, MAINTAINING THE ENVIRONMENTAL QUALITY, PARTICIPATING IN TERRITORIAL VITALITY, INSURING A CULTURAL HERITAGE AND THE QUALITY OF LIFE. THESE SERVICES PARTICIPATE IN IMPROVING THE SUSTAINABILITY OF THE DAIRY SECTORS IN THE TERRITORIES, AS WELL AS MANY ACTIONS LED BY FARMERS INTEGRATING THE IDEA OF DIFFERENTIATION STRATEGY.

DAIRY FARMERS DON'T PRODUCE ONLY MILK!

Christophe PERROT,
Economy and Territory Officer, Institut de l'Élevage (France)

FIGURE 15: THE 4 CATEGORIES OF SERVICES PROVIDED BY LIVESTOCK FARMING (SOURCE: CHARTE DES BONNES PRATIQUES D'ÉLEVAGE, 2017)



Livestock farming generates negative impacts (dysservices) on the environment, due to the consumption of inputs and greenhouse gas emissions, but also provides services (positive impacts), particularly in relation to grasslands, which help in improving the sustainability of the dairy sector in the territory (Figure 15).

Methodology to qualify the services and dysservices provided by livestock farming

In the different regions involved in the Dairy 4 Future project, focus groups were organized between April and November 2019, gathering farmers, dairy processors, advisors, researchers, NGO, local authority representatives. During these focus groups, a SWOT (strengths, weaknesses, opportunities and threats) analysis on the topic « How do we improve the sustainability of the dairy sector in the territory? » was used to identify factors which were noted to be helpful or harmful in achieving this objective (improved sustainability).

Services and dysservices should not be considered separately. Combinations of services and dysservices at a local scale reveals synergies, trade-offs and interactions. »

The different impacts (services and dysservices) proposed by the stakeholders were organized and ranked by category: provisioning (e.g., food), rural vitality, environmental quality and cultural heritage and quality of life. Transversal analysis was carried out to group similar items proposed by different regions and to rank these items by category.

Helpful and harmful factors with external origin

Factors with external origin from the system were distinguished. On the economic aspect, the growing demand for dairy products is the main helpful factor and food trends are the main harmful factor. Other harmful factors are the poor connection between consumers and farmers regarding food and the market power of retailers. The favourable pedoclimatic conditions for milk production and the remarkable ecosystems and landscape were positively highlighted. Access to land or competition for land as well as the fragmentation are detrimental. Climate change and the administrative burden caused by regulations are also a barrier to improve the sustainability of the dairy sector. Finally, Brexit is a threat for 4 regions, particularly in the North part of the Atlantic area.

Helpful and harmful factors with internal origin

Regarding factors with internal origin, many helpful elements of the supply chain are identified: existence of traditional milk field and dairy cluster, presence of specific and differentiated dairy products, public recognizing of the territorial brand/specificity.

The evaluation of the dairy processing industry is balanced. Its strong presence, especially with cooperatives is a helpful factor. However, its poor adaptability and sectorial organization is worrying, as well as its position of price maker, and reliance on commodities exporting.

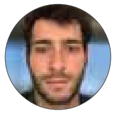
The resilience of family dairy farming and the faith in technical progress or appetite for innovation are helpful as well as the possibilities of collaborative farming, automation, ICT (Information and Communication Technology) and outsourcing to overcome workforce shortages. There is increasing requirements for farm business/management skills and the economic volatility and unprofitability of dairy farming are harmful as is the work-life balance and isolation and lack of attractiveness of dairy farming. Finally, the diversity of dairy systems maximising milk from grass/forage, high standards for milk production, circular economy and emerging renewable energy are helpful and for some areas, the reliance on grain feed/concentrates and antibiotics over use/animal disease are harmful.

During the focus group, stakeholders identified 300 items of services and dysservices, with a quite balanced distribution between categories of functions and positive or negative impacts (Table 3). A strong function of supply provides a lot of provisioning services. It is also mentioned as the basis for other functions, specifically the vitality of rural areas, as dairy farming is seen as a socially inclusive activity, and for the production of public goods. Use and valuation of grassland, by grass-based dairy farming systems, is clearly associated with positive impacts and services provided for the four categories.

TABLE 3: REPARTITION OF POSITIVE AND NEGATIVE IMPACTS OF DAIRY FARMING TO TERRITORIES

Functions	SERVICES	Services (nb items)	DYSSERVICES & CHALLENGES	Dysservices (nb items)	TOTAL (nb items)
PROVISIONING	• Strong function of supplying milk and meat with high standards of production • Efficiency thanks to technical progress • Low(er) impact thanks to circularity / autonomy, grass / pasture, manure management • Differentiated products for domestic (food security, nutrition), biotech and exports	55	• Oversupply of milk and manure • Economic uncertainty and lack in processing, marketing, competition, organisation in the supply chain (= missing market opportunities) • Impacts of the dairy expansion/ intensification on environment and animal welfare • Technical impasses (antibiotics), lack of circularity (imported feed), issues with Holstein male calves	33	88
PARTICIPATING TO RURAL VITALITY	• Provides jobs on farms, supply chain & services, rural territories • Generating « landscape economy » with access to (anthropized) nature • Providing activities (social inclusive, labour, intensive industry), life, communication, identity, skills, income in remote areas	41	• Attractiveness at stake (profitability, work pressure, paperwork). Both for paid and unpaid labour • Workforce shortage (paid), skills requirement (unpaid) • Interrogation about automation effects • Traffic of heavy machinery • Less cooperation between farmers, competition for land, misunderstanding with public	32	73
MANAGING THE ENVIRONMENTAL QUALITY	• Quality and efficiency of the resource management is favourable to biodiversity, carbon footprint, landscape, soil fertility • Closing nutrients cycles and producing renewable energy • Valorisation non arable, disadvantaged land • Fire prevention	43	• Negative impacts of Intensification/dairy expansion, on water pollution, NH4 and GHG emissions, loss of biodiversity, soil management, antibiotic use and animal health/welfare, energy or water use, plastic waste • Misunderstanding/nuisance for inhabitants (odours, flies, rodents) • Delocalized impacts of imported inputs	43	86
PRESERVING CULTURAL HERITAGE AND QUALITY OF LIFE	• Cultural/social capital maintenance • Wellbeing of vibrant rural communities, rural solidarity, mental health • The agriculture shows provide recreation and communication • Traditional way of life • Territorial identity and image (grassland, dairy products, breed)	26	• Negative impacts of intensification/dairy expansion: « efficiency treadmill », financial problems, feeling of not being valued, social/technical requirements competition between farmers • Mental hHealth (issues), isolation, burn-out • Difficulties with consumers/ citizen, disconnect from food origin • Nuisance for neighbours • Lack of public access to landscape • Lack of specific products, unfair marketing, loss of territorial cultural identity	27	53
TOTAL		**165**		**135**	**300**

DIFFERENTIATION: AN OPPORTUNITY?



Benoit BARON,
Agro-economist, Institut de l'Élevage (France)

In the Dairy 4 Future project, we were interested in actions led by different farmers in 10 regions of the Atlantic area that integrate the idea of differentiation strategy (Table 4). Being carried out only on one farm, in a small collective of few farms or even in much bigger organizations of hundreds or thousands of farms, those actions have in common the implementation of specific practices and the search of added value relying on those practices that go beyond standards and for which consumers can accept to pay more. As only one action has been studied for each region, we don't aim at being exhaustive about the diversity of actions led on territories. The common interest of all these actions is that dairy farmers from different

• DEFINITION

For a number of years, societal views toward livestock farming changed and new questions have been raised.

New societal expectations emerged concerning management and preservation of resources (water, environment, biodiversity, greenhouse gases...) but also animal feed origin (non-GMO, country of origin in conjunction with deforestation issues...) or animal welfare. In some cases, those issues can be accompanied by a willing to pay higher prices for what is considered as better agricultural practices. For farmers who pay attention to those social changes, those expectations must not be considered only as a no-confidence in livestock practices, but it can be seen as opportunities to create added-value in a new way. Adoption of new practices in order to create added value and answer those questions is what is called differentiation on dairy farms.

TABLE 4: DESCRIPTION OF THE 10 CASE STUDIES

NAME OF THE CASE STUDY	LOCATION	PRODUCTS	NB OF FARMS CONCERNED	LINK TO A COOPERATIVE	QUANTITY OF MILK CONCERNED	REQUIREMENTS	BONUS
Muuhulloa	Galicia	Cosmetics	1	No	1500 l / year	Organic milk	/
Ty Tanglwyst Dairy	Wales	Milk, cream, butter	1	No	1,2 million	Conservation and enhancing the environment	/
Behieko	Basque Country	Milk, cheese, smoothies, yoghourt	3	No	/	Organic forage, grazing all year round	/
Mossgiel organic	Scotland	bottled milk and double cream	1 + 5 (neighbours)	No	116 000 l	Organic farm, No single-use plastic on farm	/
Organic gress-fed milk MILHAFRE	Azores (Terceira Island)	Milk	14	Yes	1,5 million	100% grazing, no herbicides, no fertilizer	+ 12 cts / litre
Irish organic infant formula	Ireland	Organic infant milk	Potential of 60	Yes	/	Organic milk	/
Dromona Naturally Spreadable Butter	Northern Ireland	Butter	150	Yes	154 000 l	Diet baed on grass + dedicated feed	Til + 2,1 pence / l
Les laitiers responsables	Brittany	Milk	300	Yes	100 million litres	150 days of grazing / year, GMO free	+15 cts / litre
Isigny Protected Denomination of Origin (PDO) Butter and Cream	Normandy	Butter and cream	700	Yes		210 days of grazing, 30% of Normand breed, grasslands = at least 50% of the forage area	til + 5% on the milk price
Leite e Vida	North Portugal	Promotion of milk to consumers	/	/	/	/	/

horizons are looking for new strategies of competitiveness, out of the model of cost competitiveness. This implies more or less radical changes on their farm.

Re-appropriation of the processing and trading stages of the milk produced on the farm

Among the 10 case-studies, several of them are characterized by the re-appropriation of the processing and trading stages of the milk produced on the farm. This is the case of Ty **Tanglwyst Dairy in Wales,** a project that has allowed the creation of more than 25 jobs for a milk production of 1.2 million of litres.

That is also the way followed by three farms in Spanish Basque Country. On small organic farms (around 15 cows per farm), farmers decided to join forces for the commercial part of their activity. Thus, they created **the collective brand Behieko** and each farm participates in expanding the range of products sold, also creating employment in the territory.

In Scotland, on Mossgiel Organic Farm, a huge transition has been made after the farm went into bankruptcy in 2015 because of the dairy crisis. Bryce Cunningham rethought the business with a reduction in dairy cow numbers, a change of breed, a “cow with calf” system, and also the switch from 3 times to once daily milking. Processing of the milk and retail have also been internalised and plastic is no longer used. Even if it sounds very radical, this transition is now accompanied by a development in relationships with other local dairy farms, more classic but also in organic farming, whom the milk is processed and sold locally. However, a segmentation is made for the milk from Mossgiel Farm, considered as premium quality milk because of its particular farming practices.

In a similar approach, the **project Muuhulloa** carried out **in Galicia** by a small collective of women, making cosmetics from local milk and herbs, is also a re-appropriation of the becoming of the milk by the farmers. Even if the volumes processed are still low, rural revitalization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is at the heart of a such project and allowed employment creation in the countryside.

Production under official quality signs

Among the other studied initiatives, some of them rely essentially on official quality signs (without re-appropriation of other processing and trading stages), such as organic farming or protected designation of origin (PDO), with a certification of the practices adopted by farmers and other actors of the value chain. Those initiatives can sometimes gather a large number of farms.

« The current socio-economic context makes inflation the main concern of European consumers and does not facilitate the development of differentiated approaches, as was previously the case in the pre-2021 context. »

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In the Azores, few farms are engaged in **low input and organic dairy supply chains.** The dairy processes that milk in liquid milk which is sold mainly in mainland Portugal. Differentiation is a key point in the archipelago because of the high transport costs to reach the mainland where is concentrated Portuguese population. Milk from the Azores must be able to offer guarantees to consumers in comparison with milk from other countries of the European Union that can be more competitive on price criterion only.

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In Normandy, in the west of France, around 700 dairy farms benefit from bonuses on their milk price thanks to **PDO Isigny Butter and Cream** specific requirements, such as a minimum of 210 days of grazing a year and the use of the local Normand breed. The PDO was obtained in 1986, but it is very recently that producers have bonuses. In the past, they just had to be part of the geographical area, but with no specific remuneration, and the requirements were mainly in the processing way in dairies. Since 2020, the good reputation of the PDO products also rely on new requirements specification and contribute to bring added value on farms.

In Ireland, another important grassland region of the Atlantic area, organic milk production remains confidential and is mainly driven by small local dairies turned toward domestic market. However, the development of organic export-oriented products such as **infant formula milk** is now an emerging idea.

The use of private standards

A third way we could notice in the differentiation strategies adopted is the use of private standards that can be seen as a kind of imitation of official quality signs and aimed at proposing specific guarantees to consumers.

In a special way as it does not focus on selling differentiated milk, **Portuguese project "Leite é vida!"** ("Milk is life!") aims at meeting consumers expectations and bring them information. The goal of this project is to adopt a positive communication and bring transparency about dairy farming activity toward a wide audience.

In Brittany and other regions of France, Sodiaal cooperative launched its **"Responsible milkmen" program** in 2018. Starting from consumer survey, they drafted specifications based on the issues raised by consumers afterward. Grazing management, GMO free feed, animal welfare but also minimum price for producers emerged as key points for which consumers are willing to pay more. Finally, the products labelled under "Responsible milkmen" brand appear to be at an intermediate price between conventional and premium quality products with official quality signs.
This brand has however been stopped at the end of 2021. Despite being consumed by a loyal customer base, it was too small to ensure its sustainability in mass retail.

In Northern Ireland, Dale Farm Cooperative guarantees to its customers an **easy spreadable butter.** In comparison with Sodiaal approach, the guarantees are no longer a matter of ethical expectations of consumers but more about convenience of the product. Such a characteristic of the product is allowed by a combination of dairy cows' grazing and a specific feed supplement, resulting in a good fatty acid profile of the milk, and thus of the butter made from it. Producers involved in that initiative benefit from bonuses on their milk price. The bonus can even be higher according to the fatty acid profile measures.

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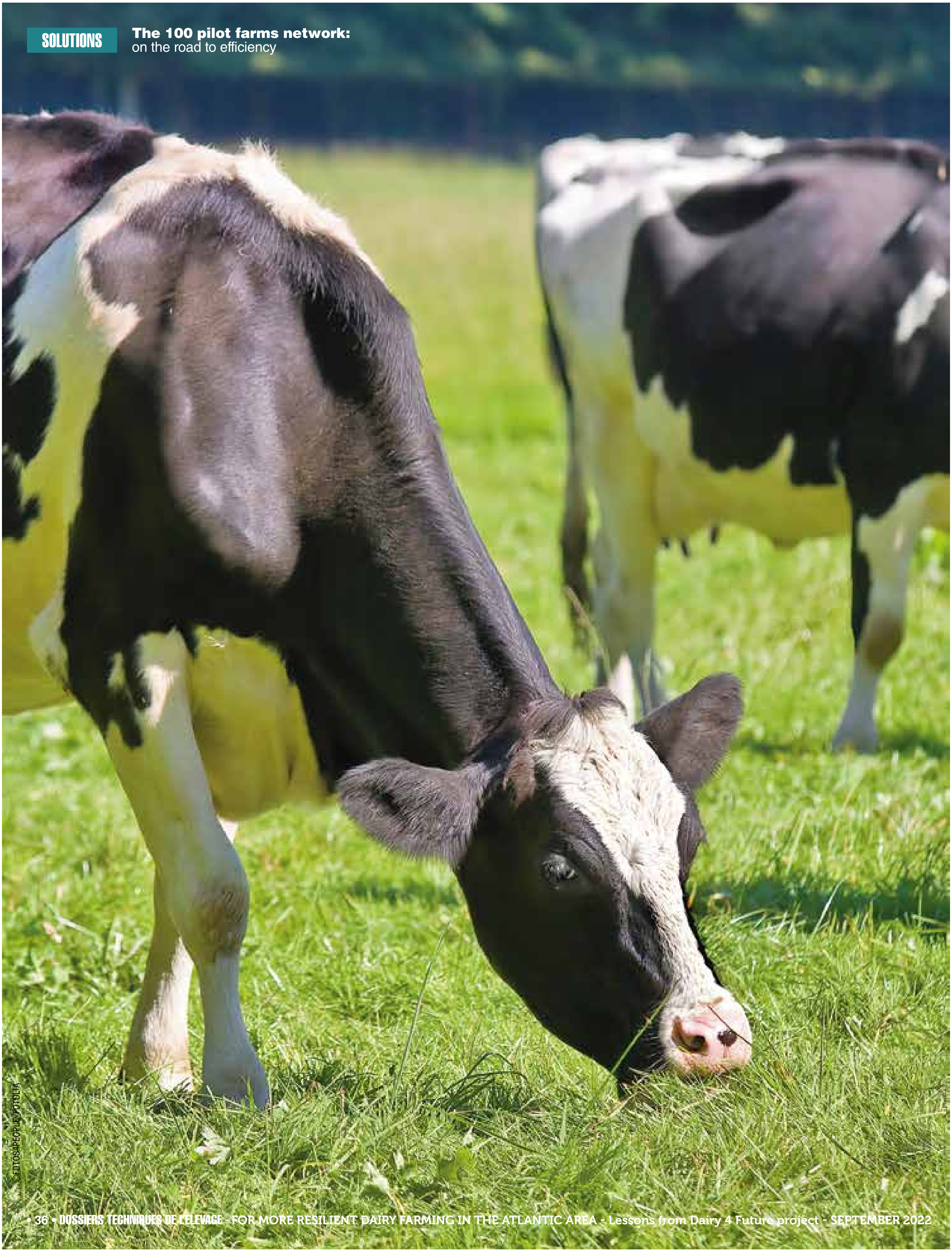


• ESSENTIAL POINTS

- There is no effect of the farming system on the net margin.
- The variable cost ratio is similar between regions, whereas the fixed costs, between depreciation, opportunity and interest costs, varies greatly between regions.
- Workforce efficiency has been shown to be a good KPI for measuring technical farm performance The top performing farms peaked at around 50 cows per person or less.
- The housed system has a higher carbon footprint (CF) than the grazing and mixed systems.
- For grazing and mixed systems, factors like age of first calving, nitrogen surplus and feed efficiency are important in determining CF.

The 100 pilot farms network: on the road to efficiency

ACROSS THE DAIRY 4 FUTURE PROJECT TERRITORY, AROUND 110 INNOVATING PILOT FARMS HAVE BEEN IDENTIFIED AND RECRUITED TO THE PROJECT. THESE FARMERS ARE SOURCES OF INNOVATIVE IDEAS AND HAVE BEEN CHOSEN AS GOOD COMMUNICATORS AND TO INSPIRE OTHER FARMERS THROUGH THEIR OWN EXPERIENCES. THESE FARMS REFLECT A RANGE OF CIRCUMSTANCES AND FARMING SYSTEMS FROM INDOOR SYSTEMS TO PASTURE BASED PRODUCTION. THEIR RESULTS HAVE BEEN ANALYSED TO BETTER UNDERSTAND THE KEYS OF THE EFFICIENCY.

THE PILOT FARMS NETWORK, TIDE OF INNOVATIVE PRACTICES

Sylvain FORAY,
Dairy 4 Future Project Manager, Institut de l'Élevage (France)

A hundred of commercial farms, for the most of them specialized in dairy production, have been recruited in all the regions involved in the Dairy 4 Future project. They are all known to be efficient and innovative. Their functioning and innovating practices in resource use can be an example for other dairy farms.

Methodology used to analyse the results and practises of the pilot farms

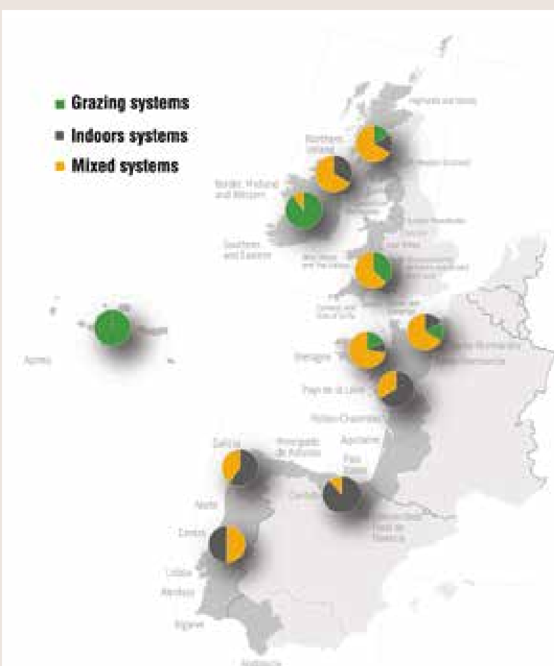
A set of data was collected to describe the dairy systems and assess the economic and environmental efficiency of these farms. In 2019, the data concerning the year 2018 were collected for the whole network. In 2020, due to the Covid-19 crisis and the health measures, the data collection was only possible for 99 farms.
The information collected relates to the description of the systems: livestock, dairy production, land use. In addition, information needed to calculate various economic and environmental indicators was collected.

The largest herds are in Scotland and South Portugal, where 5 farms have over 550 cows (see Table 5). The agricultural area of the farms in these two regions is also the largest (387 ha in Scotland and 299 ha in South Portugal). In contrast, the smallest herds are located in The Azores where the average size is 77 cows on 46 ha. The 3 French regions have the lowest number of cows per ha (1.1 for Britany and Normandy, 1.4 for Pays de la Loire). The most productive cows are found in the Basque Country (9 570 l/cow/year). They produce 3 700 litres of milk more per year than cows in Ireland.

TABLE 5: KEY FIGURES OF THE PILOT FARMS, IN AVERAGE PER REGION

Regions	NB OF FARMS	NB OF COWS	TOTAL MILK PRODUCTION (L)	MILK (L/COW/Y)	MILK SOLIDS (KG/COW/Y)	AGRICULTURAL AREA (AA) (HA)	STOCKING RATE (COWS/HA AA)	GRASSLANDS AREA/AA
Northern Ireland	10	193	1 761 696	8 461	621	140	1.4	88%
Scotland	5	420	2 848 033	6 401	494	387	1.3	97%
South west England	8	255	1 672 145	6 533	528	138	1.9	92%
Ireland	9	128	742 562	5 870	476	70	1.8	98%
Normandy	6	94	767 636	7 902	584	122	1.1	50%
Brittany	11	97	670 025	7 075	533	99	1.1	63%
Pays de la Loire	3	119	900 498	7 454	554	133	1.4	31%
Galicia	10	96	823 034	8 442	620	65	1.7	75%
Basque Country	10	221	2 010 018	9 570	665	107	2.4	81%
North Portugal	19	219	1 704 352	8 668	616	91	2.7	15%
South Portugal	4	506	4 813 803	9 808	686	299	1.9	52%
Azores	13	77	626 314	8 232	585	46	1.8	78%

FIGURE 16: LOCATION OF THE 3 DAIRY SYSTEMS OF THE DAIRY 4 FUTURE PILOT FARMS NETWORK



The three dairy systems studied

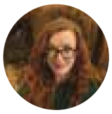
This pilot farms network gives an overview of some dairy systems but does not propose a representative sample of current dairy production in each region or countries. Indeed, the 3 main dairy systems found in the Atlantic area – Indoor systems, grazing systems and mixed systems – are represented in the Dairy 4 Future pilot farms network (Figure 16).

Indoor systems are mainly found in the south part of the Atlantic Area (Basque Country, Galicia and Portugal), in the Pays de la Loire in France, or in the Northern Ireland and Scotland.

Grazing systems are typically found in Ireland and in the Azores, but are also found in United Kingdom, Brittany and Normandy.

ECONOMIC ASSESSMENT:
MAIN KEY PERFORMANCE INDICATORS

Maggie MARCH,
Dairy system Researcher, Scotland's Rural College (Scotland)



Laura SHEWBRIDGE CARTER,
Dairy system Researcher, Scotland's Rural College (Scotland)

With growing concern about the rising costs of milk production across Europe and the United Kingdom, it is more important than ever for farmers to be able to track their financial performance and efficiency. As part of the EU Interreg Dairy 4 Future project, economic case studies were created for each participating pilot farm for two consecutive years. These case studies allow farmers to track their performance from one year to the next, as well as benchmarking their farm against others in their region.

The methodology used to study the economic results

Each regional partner appointed a farm data collector responsible for collecting financial and farm characteristic information from all pilot farms in their region for Year 1 (2018/2019) and Year 2 (2019/2020), using an adapted spreadsheet from the Dairyman project (Aarts et al., 2013). Data was uploaded to the Global Dairy Farms Model, which was used to produce individual farm economic case studies for pilot farmers for Year 1 and Year 2. Case studies included a two page "Farm Snapshot", and included profitability measures, financial efficiency measures and technical measures, which comprised of a range of Key Performance Indicators (KPIs). This was followed by a three-page summary of the farm's physical and financial data

In addition to producing case studies, two Data Envelopment Analysis (DEA) models were applied to the dataset, the first assessing efficiency of inputs controlled by farmers (land, labour, and herd size), and the second assessing financial efficiency of variable cost inputs and revenue outputs. The models were applied to EU and United Kingdom farm categories and when the data was categorised by grazing period. DEA modelling is a technique stemming from economic research which can measure the efficiency of production systems. Farms were assigned an efficiency score from each of the models and regressions were carried out with variables, such as replacement rate.

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Selected financial and technical key performance indicators

KPIs are measures collected from each area of the farm enterprise. They are representative of the general performance of the farm which have significant financial implications. Table 6 provides definitions of selected financial and the technical KPIs. KPIs specifically relate to areas within the farm system which have a significant effect on costs are particularly useful as benchmarks, considering the current trends of rising costs. For example, technical measures, such as age at first calving, calving interval, and herd replacement rate, indirectly affect costs. Farms which strive for best practice in these measures are able to improve the efficiency and the productivity of their herd, and ultimately decrease costs. Indirect KPIs such as these can be used to highlight both areas within the system which are performing well or have room for improvement. Case studies included a visual representation of each farm's KPI performance against the top performing 25% of farms in their region, in order to allow the pilot farms to assess their own performance.

• DEFINITION

KPIs: key performance indicators for dairy farmers to assess and manage their farms.

TABLE 6: SUMMARY OF MAIN CASE STUDY DEFINITION

Key Performance Indicator	Definition	Why is this indicator useful?
Profitability measures		
Output retained	Percentage of output that is left after all costs are subtracted	Standardises the profit margin, allowing farm comparison
Breakeven surplus/deficit	Amount of profit or loss per liter of milk	Indicator of whether a profit or loss is being achieved for each litre of milk being sold
Financial efficiency measures		
Variable cost ratio	Total variables costs (costs which fluctuate with production levels and herd size) as a percentage of output	Indicates what propostion of your output is being spent on variable costs, allowing for farm comparison
Fixed costs ratio	Total fixed costs (costs incurred regardless of milk production levels or herd size variation) as a percentage of output	Indicates what proportion of your output is being spent on fixed costs, allowing for farm comparison
Depreciation cost ratio	Total depreciation costs (accumulated depreciation or fixed assets) as a percentage of output	Indicates what proportion of your output is being spent on depreciation costs, allowing for farm comparison
Technical measures		
Stocking rate	Number of cows in the dairy herd per hectare of dairy allocated land	Indicator of intensity of land use on farm
Replacement rate	Percentage of milking herd culled	Can be an indicator of herd health
Milk solids par cow	The amount of milk solids being produced per cow on average	Shows the amount of milk solids produced per cow which is useful for income
Cows per person	The number of cows in the herd per full time equivalent worker (paid and unpaid)	Gives an indication of the workoad
Milk solids per person	The amount of milk solids produced per full time equivalent worker	Can be an indicator of the income per full-time equivalent worker
Age at first calving	The average age that heifers are entering the dairy herd	Can be an indicator of heifer management and pay-back of rearing costs
Calving interval	The average number of days between calving for the herd	Can be an indicator of fertlity in the herd
Margin over concentrate	The amount of profit from milk sales after the cost of concentrates	Used to monitor production costs

Main economic results

Relationship between costs and net margin: no effect of the farming system

Farmers have limited ability to influence milk price and tend to focus on controlling costs and utilising resources efficiently. One of the influencing factors that may affect business costs of pilot farms is the range of different farming methods, which have been defined as grazing (>60% grazed), mixed (<60% grazed) and housed. Generally, when considering the relationship between costs and net margin, Dairy 4 Future pilot farms with higher costs per cow tend to have lower net margins, however no of the farming system consistently had a higher net margin than another (Figure 17).

Variable cost ratio, similar between regions

When examining variable costs, which vary with management practices, variable cost ratios across the different regions involved in the project were generally similar (Figure 18). This agrees with efficiency analysis results, which found that farms reached higher efficiency scores when models focussed on costs in comparison with models focussed on resources. This suggests that the similarity in variable cost ratio between regions may be due to farms being equally efficient in managing their variable costs. The greater variability in the Year 2 data, may be due to the effects of the 2018 summer drought which were prolonged in some parts of Europe.

Fixed costs, greatly variable between regions

Fixed costs, between depreciation, opportunity and interest costs, varies greatly between regions (Figure 19). This is due to

FIGURE 17: RELATIONSHIP BETWEEN ECONOMIC COSTS (€/COW) AND NET MARGIN (€/COW) FOR DAIRY 4 FUTURE PILOT FARMS, BASED ON ECONOMIC DATA COLLECTED IN YEAR 1 AND YEAR 2, CATEGORISED BY SYSTEM

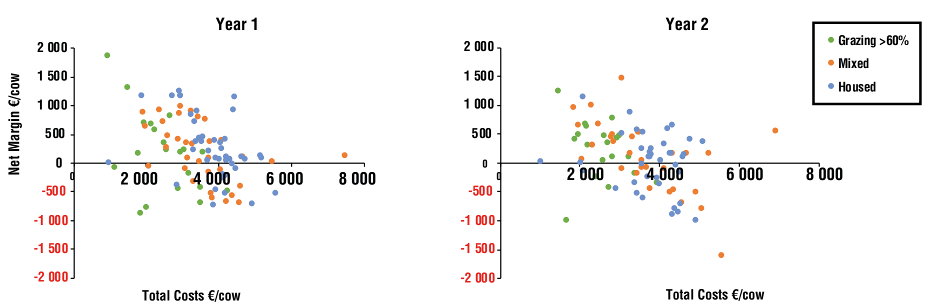


FIGURE 18: VARIABLE COST RATIO (%) FOR DAIRY 4 FUTURE PILOT FARMS, BASED ON ECONOMIC DATA COLLECTED IN YEAR 1 AND YEAR 2, CATEGORISED BY REGION. VARIABLE COST RATIO IS DEFINED AS VARIABLE COSTS A PERCENTAGE OF TOTAL REVENUE.

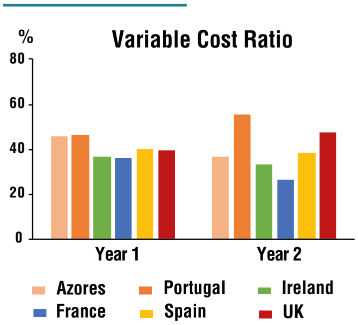
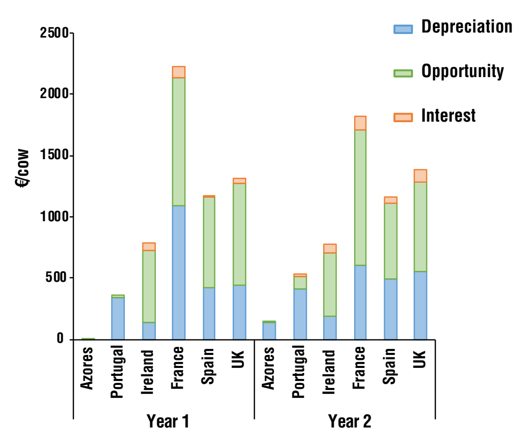


FIGURE 19: BREAKDOWN OF FIXED COSTS (€/COW) FOR DAIRY 4 FUTURE PILOT FARMS, BASED ON ECONOMIC DATA COLLECTED IN YEAR 1 AND YEAR 2, CATEGORISED BY REGION. FIXED COSTS HAVE BEEN GROUPED INTO THREE CATEGORIES: DEPRECIATION, OPPORTUNITY, AND INTEREST.



a combination of the effect of climate, which in turn can influence farming method. For example, The Azores systems remains at very low fixed costs due a farming method, which is influenced by a climate and that requires little investment in farm infrastructure. In contrast, French farms have high fixed costs. This is partly related to the farming methods, which can lead to high equipment and building depreciation costs. However, French farms also have the highest opportunity costs of any Dairy 4 Future region, which is associated with high unpaid workforce costs. France reports the highest hourly unpaid workforce cost, at €20.60/h, almost €10 more than the next highest region.

Paid worker hourly rate: French regions at the top

In addition to France having the highest hourly rate for unpaid workforce, French farms make up the majority in the top 20 farms in the project in terms of paid worker hourly rate (Figure 20). When, in an online survey, farmers participating in the project are asked about whether the availability of workforce is favourable or unfavourable to the success of their dairy operation, only France and the United Kingdom found workforce availability favourable. The positive answer from French farmers may be linked to a competitive and attractive paid hourly rate for workers. The survey was conducted in 2020, before the full extent of Brexit was felt on the workforce supply available in the United Kingdom and if the survey was to be conducted in 2022/2023, UK farmers may now find workforce availability unfavourable to their operations.

Workforce efficiency: optimum around 50 cows/person

Workforce efficiency has been shown to be a good KPI for measuring technical farm performance and can be tracked using multiple methods (Wilson, 2011; Gonzalez-Majia et al., 2018; Yi and Ifft, 2019). One such method, presented to farmers in their case studies is workforce efficiency in terms of cows per person with regards to net margin (Figure 21). The top performing farms in the project with regards to net margin peaked at around 50 cows per person or less.

FIGURE 20: PROJECT FARMS ORGANISED FROM LOWEST PAID WORKER HOURLY RATE TO HIGHEST PAID WORKER HOURLY RATE, BASED ON ECONOMIC DATA COLLECTED IN YEAR 1 AND YEAR 2, CATEGORISED BY REGION (TOP 20 REFERS TO THE 20 FARMS WITH THE HIGHEST PAID WORKER HOURLY RATE)

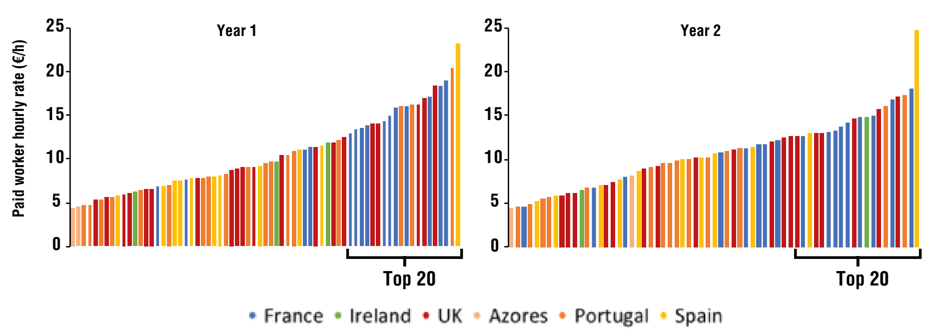
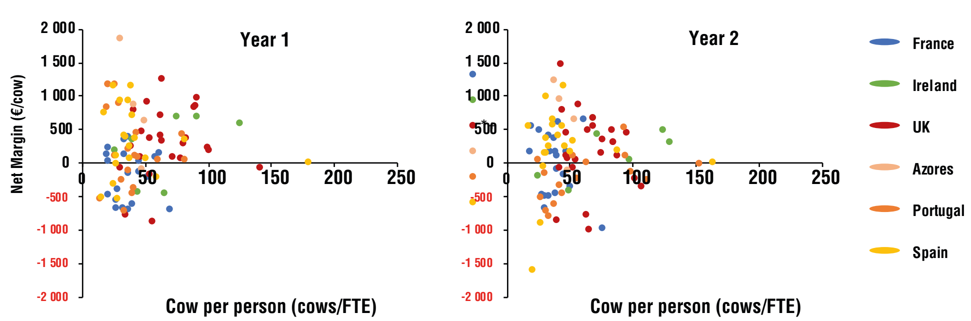


FIGURE 21: RELATIONSHIP BETWEEN NET MARGIN (€/COW) AND LABOUR EFFICIENCY, IN TERMS OF COWS PER PERSON (COWS/FULL-TIME EQUIVALENT) FOR DAIRY 4 FUTURE PILOT FARMS, BASED ON ECONOMIC DATA COLLECTED IN YEAR 1 AND YEAR 2, CATEGORISED BY REGION



This agrees with research that found the optimum number of cows per person being between 40-60; below this level, workforce does not appear to be utilised efficiently and above this level, a drop in gross profit can be observed (Stokes et al., 2007). Project farms with higher cows per person, potentially with the aim of reducing labour costs to increase net margin, appear to create a false economy and decreasing workforce efficiency. However, many project farms with a negative net margin have lower numbers of cows per person, suggesting workforce inefficiency, which is not affected by region or system type

Workforce was defined as full-time equivalent (FTE) and with each FTE defined with a different number of working hours per year, set by the farm, a stronger labour efficiency relationship might have been found if it had this been standardised or if workforce efficiency measured as a function of hours per year.

Herd replacement rate, interesting KPI

Herd replacement rate, which can be an indicator of herd health and management, can be a useful KPI from an economic perspective. Increased herd replacement rates have previously been linked to increased costs (Hadley et al., 2006). Pilot farms have also followed this trend, with farms having higher replacement rates, primarily seen in housed systems, tending to have higher costs (Figure 22A). Considering that housed systems in general tend to have higher costs than mixed or grazed systems, it is unsurprising that if the majority of farms with higher replacement rates are housed systems, a relationship between system and replacement rate can be seen. A regression analysis to assess the effect of replacement rate on farm efficiency scores produced by DAE model 2 (cost efficiency model) found that replacement rate had a significant effect on UK farm efficiency scores, but not EU farm scores. Generally, the majority of UK farms had replacement rates lower than 30% (Figure 22B) and was coupled with lower costs than EU farms (average UK costs = €3,033; average EU costs = €3,746).

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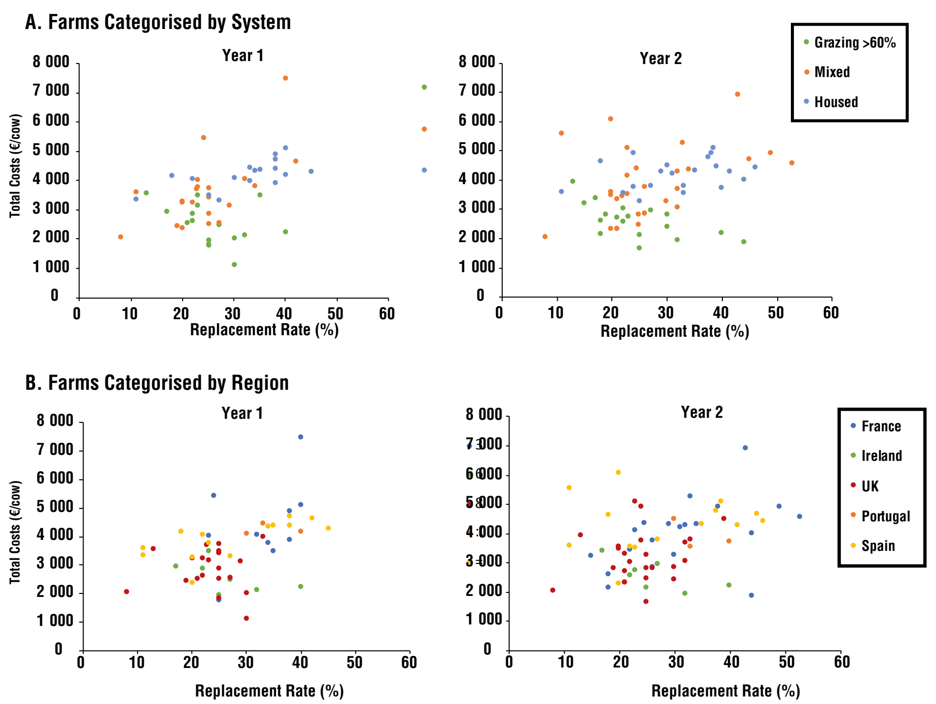
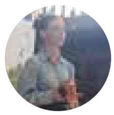
FIGURE 22: RELATIONSHIP BETWEEN TOTAL COSTS (€/COW) AND REPLACEMENT RATE (%), FOR DAIRY 4 FUTURE PILOT FARMS, BASED ON ECONOMIC DATA COLLECTED IN YEAR 1 AND YEAR 2, CATEGORISED A) BY SYSTEM AND B) BY REGION



THE ENVIRONMENTAL ASSESSMENT

James HUMPHREYS,
Research Officer, Teagasc (Ireland)



Marion SORLEY,
Research Assistant, Teagasc (Ireland)

The environmental impact of the pilot dairy farms is calculated using a tool called Life Cycle Assessment (LCA). The goal of LCA is to assess the environmental impacts associated with a product, in this case, milk. The environmental impact we have assessed in Dairy 4 Future project are the 3 main greenhouse gas GHG (Methane, Nitrous Oxide and Carbon dioxide) and ammonia emissions.

Scope of the environmental evaluation and methodology

The emissions counted in the environmental analysis include everything up to the farm-gate, or in other words *cradle to grave*, as shown in the figure 23.

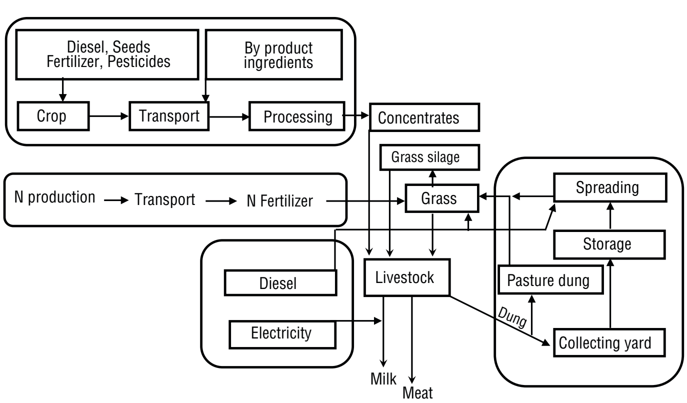
The carbon footprint (CF) is commonly expressed in terms of product (kg of CO_2 equivalents/kg of milk) and is the unit used in the results below. The ammonia footprint is expressed in kg NH_3 per ha of land on which the milk is being produced as ammonia emissions deposit locally.

To help identify GHG emissions' hotspots, the CF is broken down into 6 categories:

1. Emissions from **enteric fermentation** describe the CH_4 emitted from the cow from the process of digestion. The more a cow eats, the greater the amounts of methane emitted however, it is also dependent on diet and individual cow efficiency.
2. **Manure management** emissions are CH_4 and N_2O from the excretion, storage and spreading of manure. Whether a cow deposits dung and urine in a tank or outside at pasture, if the tank is covered, temperature, are some of the factors affecting these emissions.
3. **Fertiliser** emissions include the production and spreading of fertiliser on farmland.
4. **Concentrate** emissions are from the production of the imported concentrate feeds like soybean meal and pelleted ration.
5. **Fuel** emissions include combustion of diesel.
6. **Other** emissions include agrochemical and plastic production and crop residues.

We calculate emissions in each of these categories by taking the raw data or a measurement of the activity that is producing the emissions and use it in an equation with an estimated emission factor (EF) that determines the degree to which GHGs are emitted.

FIGURE 23:
A FLOWCHART OF THE "CRADLE TO FARM-GATE" MILK PRODUCTION SYSTEM REPRESENTING THE PROCESSES INCLUDED FOR DESCRIBING A TYPICAL DAIRY UNIT (CASEY AND HOLDEN, 2005)



• BENCHMARKS

The GHG emissions vary in global warming potential (GWP), i.e. how much heat the GHG can trap in the atmosphere up to a specific time horizon. The GWPs for a time horizon of 100 years are the following:

- Methane (CH_4): 28;
- Nitrous Oxide (N_2O): 265;
- Carbon dioxide (CO_2): 1.

In other words, nitrous oxide is most effective at trapping heat and carbon dioxide is the least.

• TO KNOW ABOUT

AMMONIA (NH_3) IS ANOTHER AIR POLLUTANT BUT IS NOT A GREENHOUSE GAS.

It is harmful to the environment because it causes acidification of our ecosystems, having harmful effects on residing species, especially in sensitive ecological areas. Furthermore, the re-deposition of ammonia releases N_2O.

Calculating emissions from farms, especially those from biological relationships like enteric fermentation, can have high uncertainties due to the inherent and complex nature of the system. As research continues, the EFs we use can become more accurate. Studies like Dairy 4 Future help us to tie it all together and look at the system as a whole, identify where we can reduce emissions and where there may be pollution swapping.

To assess the wide variety of farming systems in the Dairy 4 Future project, we categorised the farms into GRAZING (cows are grazing fresh grass for more than 60% of the time), MIXED (less than 60% grazing) and HOUSED (cows are indoors all year round) (Table 7).

The housed system has more than double the stocking rate of the grazing and mixed systems due to a large proportion of feed being imported and manure being exported off-farm. The higher levels of concentrate feeding allow for greater milk yields however, are also correlated with higher replacement rates than the grazing and mixed systems. In comparison, the grazing system relies on pasture for majority of the cow's diet and is driven by high levels of chemical fertiliser nitrogen. The grazing and mixed systems have the highest nitrogen use efficiency due to some of the farms relying on legumes such as white clover for biological nitrogen fixation, and seven of these farms are organic.

Carbon footprint results: higher for the housed system

The table 8 shows the carbon footprint (CF) in kilograms of carbon dioxide equivalents per kilogram of fat and protein corrected milk. The CF has been allocated according to the economic value of milk and meat. On average, 90% of dairy farm emissions can be attributed to milk, and 10% to meat.

The housed system had a higher ($P<0.001$) CF than the grazing and mixed systems and a different emissions profile (Table 8). When looking at individual variables against CF, milk yield was important for housed systems but not for grazing and mixed (Figure 24). A stepwise regression of the housed systems showed that uncovered slurry storage, feed efficiency, concentrate use and milk yield per cow explained 72% of the variation in the CF of these farms. Milk yields greater than 10,000 kg FPCM/cow in the housed systems resulted in CFs in line with the grazing and mixed systems' CF.

For grazing and mixed systems, factors like age of first calving, nitrogen surplus and feed efficiency were important in determining CF.

TABLE 7: KEY FARM CHARACTERISTICS FOR THE 3 SYSTEMS

	GRAZING SYSTEM	MIXED SYSTEM	HOUSED SYSTEM
Stocking density (LU/ha)	2.04	1.99	4.20
Replacement rate (%)	24	28	31
Cows, % time spent grazing	68	42	0
Annual milk production (kg FPCM/cow)	5,889	8,371	9,793
Bought-in concentrate (kg/LU/year)	701	1,088	1,983
Bought-in forages (kg/LU/year)	0.00	0.97	4.37
Fertiliser use (kg N/ha)	215	132	123
N surplus (kg N/ha)	223	192	422
N use efficiency	0.48	0.38	0.33
P surplus (kg P/ha)	13	15	42
P use efficiency	0.77	0.72	0.52

TABLE 8: CARBON FOOTPRINTS AND BREAKDOWN OF EMISSION SOURCES FOR THE 3 SYSTEMS

	GRAZING SYSTEM	MIXED SYSTEM	HOUSED SYSTEM
Carbon Footprint (kg CO_2 eq./kg FPCM)	1.14	1.23	1.51
Categorical breakdown of GHG emissions %:			
Enteric Fermentation	52	47	34
Manure	12	16	25
Fertiliser	14	7	4
Concentrate	13	24	29
Fuel	3	3	3
Other	6	3	5
Ammonia (kg NH_3/ha)	50	68	216
Categorical breakdown of ammonia emissions, %:			
Housing	23	29	33
Manure storage	9	18	24
Manure application	36	40	41
Chemical fertiliser	19	4	1
Unmanaged manure (grazing)	14	10	1

Utilization of legumes such as white clover for nitrogen fixation can help in reducing greenhouse gas emissions in grazing and mixed systems.

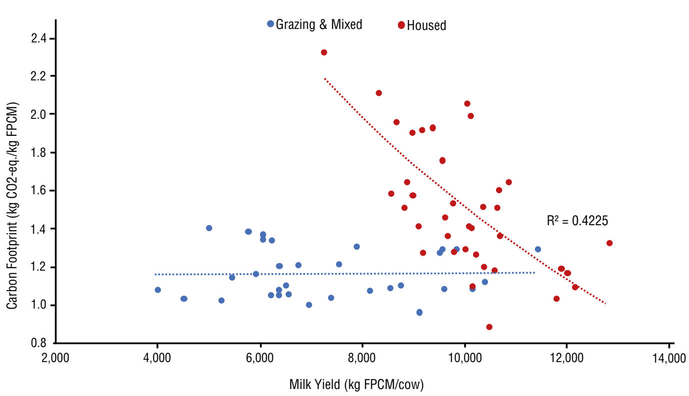
• REFERENCE

Casey, J. W. and N. M. Holden, 2005. Analysis of greenhouse gas emissions from the average Irish milk production system. Agricultural Systems 86(1): 97-114.

Ammonia emissions were highly correlated with stocking rate hence the ranking seen in Table 8. Using low emissions slurry spreading, covered slurry stores, use of protected urea and legumes, use of lower crude protein rations will help reduce nitrogen surplus and ammonia emissions.

Feed efficiency, how well feed is converted to milk, is an important factor in all systems and can be improved by selecting more efficient cows and feeding greater quality feed. Other strategies such as improving age at first calving, reducing fertiliser use or switching to protected urea, utilization of legumes such as white clover for nitrogen fixation, improving grass utilization and quality are important in reducing emissions in grazing and mixed systems. Analysis of the housed system showed that mitigation strategies such as covering manure storage and reducing concentrate input can be very effective at reducing carbon footprint.

FIGURE 24:
RELATIONSHIP BETWEEN ANNUAL MILK OUTPUT PER COW (KG FPCM/COW) AND THE CARBON FOODPRINT (KG CO2EQ./KG FPCM) ON THREE DIFFERENT SYSTEMS OF MILK PRODUCTION IN THE ATLANTIC AREA.



BLUEPRINT SYSTEMS: A ROAD MAP FOR LOW EMISSIONS DAIRY FARMS IN ATLANTIC AREA

César RESCH ZAFRA,
Researcher in dairy production, Centro de Investigacións Agrarias de Mabegondo (Galicia)

The goal is to design a useful road map for farms across the Atlantic area to improve their economic and environmental performance.

Methodology

Among more than one hundred variables available, some were chosen by how significant they were in terms of explaining variability either in economic or environmental topics. Once chosen these variables from selected farms were sorted by the values of these variables and divided in four groups with the same number of farms each, for quarters of farms are created following this criteria *High, Medium High, Medium Low* and *Low.*

Action levers to improve economics and lower environmental impact of dairy farming

In the rest of analysed variables, some of them gave some clues of how-to perform at farm level to improve economics and lower environmental impact.

Link between Replacement heifers and Stocking rate

In Table 9, eighty farms were sorted by their stocking rate: those twenty with higher stocking rate in livestock units (LU) per hectare were allocated in group *"High"* and so on with the other three groups. Once sorted on every variable of every group, an ANOVA analyses was carried out. Replacement heifers were significant and *High* farms in terms of stocking rate are those with higher replacement heifers rate and so on with the rest of groups. Then the farms in *Low* group attending to stocking rate are those with a lower replacement heifers rate.

Table 10, following the same methodology, links stocking rate with carbon footprint per kilo of fat and protein corrected milk (FPCM). The ANOVA gives information about significance between groups: the twenty farms with higher carbon footprint are those with higher stocking rate.

With these two first approaches, it seems that surface plays an important role in low carbon footprint (CF) emission in farms, those farms with the lowest CF have a lower stocking rate and these farms with low stocking rate are those with the lowest replacement heifer's ratio.

TABLE 9: LINK BETWEEN STOCKING RATE AND % OF REPLACEMENT HEIFERS

Stocking rate (LU per ha)	NUMBER OF FARMS	REPLACEMENT HEIFERS (%)	SIGNIFICANCE ($P<0,05$)
High farms	20	43%	a
Medium High farms	20	37%	ab
Medium Low farms	20	34%	ab
Low farms	20	31%	b

TABLE 10: LINK BETWEEN CARBON FOOTPRINT AND STOCKING RATE

Carbon footprint (per kilo of FPCM)	NUMBER OF FARMS	STOCKING RATE (LU PER HA)	SIGNIFICANCE ($P<0,05$)
High farms	20	2.98	a
Medium High farms	20	2.50	ab
Medium Low farms	20	2.21	ab
Low farms	20	2.09	b

Link between Purchased feed and Carbon footprint

With the same method as described before, farms were sorted depending on money spent in purchased feed per kilo of

solids in milk (fat + protein) produced. This variable measures how efficient a farm is in terms of feeding the animals. Net profit in the case of our sample hides farms´ efficiency because milk price is very different between farms of different regions. This is the reason why purchased feed was chosen to be analysed instead of net profit or other variables.
Carbon footprint per groups sorted by euros spent in purchased feed per kilo of milk solids produced is showed in table 11. **Those farms with lower expenditures in purchased feed are those with lower CF,** this difference is clear between farms in Low and High groups. Farms in low expenses groups have a 40% average lower CF than those farms in groups with higher expenses in feed.

TABLE 11: LINK BETWEEN PURCHASED FEED PER KILO OF MILK SOLIDS AND CARBON FOOTPRINT

Purchased feed per kg of milk solids (€)	NUMBER OF FARMS	CARBON FOOTPRINT (PER KILO OF FPCM)	SIGNIFICANCE (P<0,05)
Medium Low farms	20	0.98	a
Low farms	20	1.03	a
Medium High farms	20	1.68	b
High farms	20	1.75	b

Link between Carbon footprint and Variable costs

Carbon footprint seems to be a good indicator of efficiency at a farm level. Efficiency means good use of resources and therefore this efficiency should be related with economics. To be more efficient in any system also means less by-products and lower pollution. This is theory and in the case of these eighty farms analysed seems to be true.
Sorting farms by total variable costs and creating four groups, found that **farms with lower variables costs,** those costs related with farms´ performance and how resources are used at farm level, **are farms with lower carbon footprint** (Figure 25).

FIGURE 25: LINK BETWEEN TOTAL VARIABLE COSTS AND CARBON FOOTPRINT

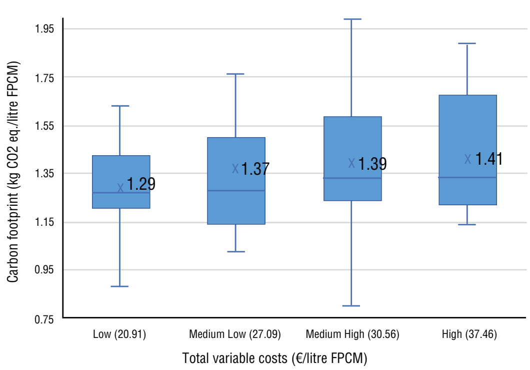


Figure 25 gives information about relationship between CF and total variable costs. These include cattle rearing costs (concentrates, off farm fodder, hygiene and vet), crop related costs, operation costs and land and building maintenance.
Paid and unpaid labour is not included in this concept. The idea was to try to identify a variable closely linked to herd husbandry, excluding those that are deeply affected by unitary prices like labour or net profit, this last with strong association with milk price.
Once sorted by farms considering their total variable costs in euros per 100 litres, farms were gathered in four different groups. *Low* farms with the lowest variable costs in this group of farms had a mean of 20,91€ of total variable costs per 100 litres of fat and protein corrected milk, for *Medium Low* this figure was 27,09 ; in *Medium High* 30,56 and farms with the *highest* total variable costs gave a mean of 37,46€ of total variable costs.
The average carbon footprint of farms in every group was assessed (figure 25). Differences between groups were not statistically significant, but at average level lower expenses means lower CF and the group of farms with the highest expenses have the highest average CF, with caution it was appreciated that **carbon footprint seems to be a good benchmark in terms of economic health of farm.**

Future road map for dairy farms

The dairy industry has a significant challenge ahead, because to some extent it has been unfairly blamed for being a main source of GHG on earth. Now the goal is to create a positive atmosphere and to assume that our activity to produce food for humans, as any other activity, has an environmental impact, but this activity is inherent to human existence.
The amount of GHG coming from food industry is mainly due to the growth of

world population. Sixty years ago, population was one third of the present situation. The three main factors to take into account to calculate food GHG impact are: number of humans beings, impact of producing a diet in terms of GHG and type of diet consumed by humans. The first issue is the one which modifies agricultural impact on global GHG emissions, the others two has an influence but is minor compared to the first one.

If the textile industry or transport sector did the same calculation, it is clear that they answered to growth population demands but if units consumed of textile or transport are considered, the increase of unitary consumption of items under these two categories is huge compared to the amount of food eaten by every human now or sixty years ago that mostly remains the same.

The food industry, and dairy sector in particular is very well prepared to give answer to growing demands to improve production systems. One of the main goals of this Dairy 4 Future project was to discover solutions for our farms to produce with lower GHG whilst maintaining or improving their economic performances.

The link between CF and economics makes sense, and those farms with lower CF are those with better conditions for a cheaper cost of production. This means that every measure of improvement implemented in a system to get a lower GHG impact will probably improve farm net profit.

Availability of land plays an important role to reduce CF: farms with higher stocking rates are those with higher CF per litre of milk. This land availability is linked to some factor affecting emissions: self-sufficiency to produce local feed for cows and heifers, availability of this land to fix carbon on soil and better use of slurry are some of reasons that make land a key point to reduce CF at farm level.

Replacement heifers' rate is another important point to be considered. Every heifer that calves in a dairy farm is for twenty some months realising CO_2 equivalent gases without producing a single litre of milk. Farms with higher replacement heifers' rate are those with higher CF per litre of milk. To measure milk produced per cow and day in the whole life is a good benchmark that combines age at first calving, cow´s longevity and lifetime production. To achieve a compromise between these three issues leads dairy farms to a better economic and environmental performance and therefore to a CF improvement.

« It is primordial to observe a global and integrated approach to the different factors involved in the functioning of dairy systems in the evaluation of their environmental performance. Complementary and multidisciplinary approaches need to be devised to better define trade-off situations, depending on local or more global issues. »

Precision farming appears as indicator of good practises at farm. Those farms with lower expenses in concentrate per litre of milk produced are the lowest in carbon footprint emissions. This good use of resources is key to achieving a low impact on environment. This is not a matter of minimising the amount of concentrate per cow and is concerned with being more accurate in terms of feeding the animals. It is a very extended practise to feed all the animals the same regardless of any performance indicator, this total mixed ration system should be replaced and cows should be fed depending on benchmark index combining body condition score, days in milk, milk yield and others. The technological challenge is to produce 40 litres of milk per cow with 8 kilos of concentrates. This requires excellent dairy cow management and a very good forage quality. This is the same if cows are in a pasture-based system, because making a more accurate system is also a challenge under these conditions.

These given solutions are good practises at farm gate that help farmers to reduce their carbon footprint impact on atmosphere. In time these practises and others will be part of indicators that will likely be part of credit carbon system, that once launched will make boundaries of dairy farm production at farm gate.

PILOT FARMERS' TESTIMONIES

Some of the pilot farms studied in Dairy 4 Future project are presented in a summary sheet, containing the farmers' testimonies on the technical levers they have established on their farms to be more efficient. Videos were shot in some of these farms.
Those sheets and videos are shared on Dairy 4 Future project website : https://dairy4future.eu

Eight of these testimonies are presented in the following pages.

Testimony:

Anthony KERVORGANT (Brittany)

Dairy 4 future — Interreg Atlantic Area

Anthony KERVORGANT
Pont Scorff
2019

PILOT FARM

LABOUR

- 2 labour units including 1 employee

THE DAIRY HERD

- Livestock Units (LU): 97
- Dairy cows – Breed: 61 Prim'Holstein
- LU dairy heifers: 26
- Caving period(s): All the year

PRODUCTION

- Liters sold: 461 800
- % fat and protein content: 4,02 / 3,25
- Liters sold/cow/year: 6 800
- Liters/ha forage area: 6 100
- Stocking rate : 1,3 LU/ha forage area

BUILDINGS

Dairy cows
- Milking system: 2*5 units
- Stable: 60 stalls with straw

Heifers and calves
- Bedding system: straw bedded
- Boxes: individual boxes for calves

OBJECTIVES

Production cost management

Equipment longevity and its maintenance cost limitation

Optimization of the income in relation to the work time

INNOVATIONS TO DISCOVER

Consistency between the production system and work time

Low concentrates input

Grassland management

AGRICULTURAL AREA

Total 105 ha Agricultural Area
- Permanent grassland: 9 ha
- Temporary grassland: 53 ha
- Maize silage: 14 ha
- Wheat: 20 ha
- Corn: 4 ha
- Rape: 5 ha

VIDEO

SCAN ME

HIS TESTIMONY

Why did you join the Dairy 4 Future project?

"What attracted me was the opportunity to compare my ideas with other farmers and to see other dairy practices. In short for me, it was the open-mindedness."

What do you take away from the project?

"I take away that any production model can work if it is in an understanding with its environment. According to me, the major theme of future work is the adaptation of livestock to climatic and societal issues in order to remunerate the work of the farmer.

Testimony:

EARL Morille (Pays de la Loire)

Dairy 4 future

Interreg Atlantic Area

EARL Morille Chemillé en Anjou 2019

PILOT FARM

INNOVATIONS TO DISCOVER

Automated heat detection and rumination monotoring (collars)

Automatic milk feeder for calves

On-farm feed fabrication

THE DAIRY HERD

- Livestock Units (LU): 111
- Dairy cows – Breed: 77 Prim'Holstein
- LU dairy heifers: 34
- Calving period(s): All the year

PRODUCTION

- Milk sold: 715 500 litres
- % fat and protein content: 4.25 / 3.23
- Milk sold/cow/year: 9 330 litres
- Milk sold/ha forage area: 17 040 litres
- Stocking rate : 2.7 LU/ha forage area

BUILDINGS

Dairy cows
- Cubicles with scraped alley ways
- Milking system: 1 robot

Heifers and calves
- Collective boxes on straw litter

DAIRY COWS NUTRITION

Forage (kg DM/cow/year)
- Grazed grass: 250
- Grass silage: 1 000
- Maize silage: 4 130
- Wheat straw: 150
- Cocksfoot straw: 150
- Grass wrapping: 250

Concentrates (kg FM/cow/year)
- Soya cake: 1 200
- Cereals: 470

AGRICULTURAL AREA

Total 77 ha Agricultural Area
- Permanent grassland: 2 ha
- Temporary grassland: 15 ha
- Maize silage: 25 ha
- Cocksfoot seed: 7 ha
- Sales crops: 28 ha
- Forage area: 54%
- Grassland/Forage area: 39%

HIS TESTIMONY

"Since the beginning of the Dairy 4 Future project, our group of French pilot farmers has had the opportunity to meet on several occasions to discover or learn more about the dairy sector in the different regions of the Atlantic area. Our meetings allowed us to visit our respective farms, present our breeding systems, and share our work methods, and even to transfer or test practices on our respective farms. We visited the French experimental farms involved in the project, discuss the trials conducted and most importantly present our expectations and needs.

We were also delighted to travel to Ireland in June 2022 to visit the pastures of our Irish colleagues!"

1

Testimony:

BC n°3 (Basque Country)

Dairy 4 future — Interreg Atlantic Area

Dairy Farm n°3 Basque Country 2019

INNOVATIONS TO DISCOVER

Organization of the working team (generational replacement)

Slurry separator and injector equipment

Rubberized floor and composted bed

Some direct sale of fresh milk

THE DAIRY HERD

- Livestock Units (LU): 292
- Dairy cows – Breed: 235 Prim'Holstein
- LU dairy heifers: 79
- Calving period(s): All the year

PRODUCTION

- Milk sold: 2 628 300 litres
- % fat and protein content: 3.71 / 3.43
- Milk sold/cow/year: 12 700 litres
- Milk sold/ha forage area: 32 850 litres
- Stocking rate : 3.0 UGM/ha forage area

BUILDINGS

Dairy cows

- Barn: composted bedding
- Milking system: 1 rotatory, 3 times/day

Heifers and calves

- From 0 to 6 months: straw bedding
- After 6 months: rubber mat

DAIRY COWS NUTRITION

Forage (kg FM/cow/year): 59%

- Dehydrated alfalfa: 5
- Grass silage: 6
- Maize silage: 21

Concentrates: 41%

OBJECTIVES

1. Diversification of products in the market.
2. Search for alternative sources of energy

AGRICULTURAL AREA

Total 96 ha Agricultural Area

- Permanent grassland: 35 ha
- Temporary grassland: 25 ha
- Maize silage: 25 ha
- Vetch: 25 ha
- Others (forest): 11 ha
- Grassland/Forage area: 60%

HIS TESTIMONY

Why did you join the Dairy 4 Future project?
"We are interested in learning about other successful working methods and how we can adapt them to improve our milk production".

What do you take away from the project?
"We have made ourselves known to the public and the dairy sector in European regions. We are part of an interesting network that may help to assess the implementation of innovations that can improve the continuity of dairy production in these difficult times".

Testimony:
A Cernada (Biofarm) (Galicia)

Dairy 4 future
Interreg Atlantic Area

A Cernada (Biofarm)
Galicia
2021/2022

THE DAIRY HERD
- Dairy cows – Breed: 75 Mix
- LU dairy heifers: 20
- Calving period(s): All the year
- Age at first calving: 27 months

PRODUCTION
- Milk produced: 420 000 litres
- Milk sold (own brand): 36 000 litres
- Milk sold/cow/year: 5 600 litres
- Milk sold/ha forage area: 6 000 litres
- Stocking rate : 1.36 LSU/ha forage area

BUILDINGS
Dairy cows
- Straw litter
- Milking system: 2 x 4 places

Heifers and calves
- From 0 to 3 weeks: individual boxes
- After 3 weeks: Collective boxes on straw litter till 9 months

DAIRY COWS NUTRITION
Forage (kg DM/cow/year)
- Grazed grass: 2 550
- Grass silage: 450
- Maize silage: 1 050
- Hay: 200

Concentrate (kg FM/cow/year)
- Lupines: 220
- Cereals: 800
- Peas: 250
- Others: 400

INNOVATIONS TO DISCOVER
Own mill to make concentrate

Bio fresh milk bottled and delivered from farm to consummers

AGRICULTURAL AREA
Total 70 ha Agricultural Area
- Permanent grassland: 60 ha
- Temporary grassland: 10 ha
- Grazing area: 60 ha
- Maize silage: 10 ha
- Forage area: 85%

VIDEO

HIS TESTIMONY
Why did you join the Dairy 4 Future project?

"This project gives us the opportunity to present our way of working and our objectives to the members of the different entities ».

Testimony:

Eugénio CÂMARA (Sao Miguel, Azores)

Dairy 4 future
Interreg Atlantic Area
European Union

Eugénio Câmara
Sao Miguel, Azores
2019

INNOVATIONS TO DISCOVER

Animal welfare with special attention to heifers

Concentrated feed supplied according to milk production

Slurry management

« Happy cows » program

THE DAIRY HERD

- Livestock Units (LSU) : 181
- Dairy cows – Breed: 136 Holstein
- LU dairy heifers: 41.6
- Calving period(s): All the year
- Age at first calving: >24 months

PRODUCTION

- Milk produced: 956 596 litres
- Milk sold (own brand): 956 596 litres
- % fat and protein content: 3.7 / 3.2
- Milk sold/cow/year: 7 033 litres
- Milk sold/ha forage area: 17 082 litres
- Stocking rate : 3.2 LSU/ha forage area

BUILDINGS

Dairy cows

- Stable: 2 main buildings
- Milking system: fixed, with 16 places
- 2 milking periods of 3 h (time spent in barn)

Heifers and calves

- Individual boxes
- Bedding system: straw

DAIRY COWS NUTRITION

Forage (kg DM/cow/year): 5 840

- Grazed grass: 1 460
- Grass silage: 1 825
- Maize silage: 2 555

Concentrate (kg DM/cow/year): 3 212

AGRICULTURAL AREA

Total 56 ha Agricultural Area

- Permanent grassland: 42 ha
- Temporary grassland: 14 ha
- Maize silage: 14 ha
- Forage area/AA: 100%
- Permanent grassland/Forage area: 75%
- Feed self-sufficiency for forage: 100%

HIS TESTIMONY

Why did you join the Dairy 4 Future project?

" I have joined the project because I want to know the carbon footprint of my farm and identify solutions to decrease it."

What do you take away from the project?

" Joining the project has allowed me to take good examples from other regions in Europe".

Testimony:

José Antonio AZEVEDO (Terceira, Azores)

Dairy 4 future

Interreg Atlantic Area

José Antonio Azevedo
Terceira, Azores
2019

THE DAIRY HERD

- Livestock Units (LSU) : 247
- Dairy cows – Breed: 150 Holstein
- LU dairy heifers: 35 (<2 years) + 79 (>2 years)
- Calving period(s): All the year
- Age at first calving: >24 months

PRODUCTION

- Milk produced: 1 250 000 litres
- Milk sold: 1 250 000 litres
- % fat and protein content: 3.9 / 3.2
- Milk sold/cow/year: 8 400 litres
- Milk sold/ha forage area: 12 600 litres
- Stocking rate : 1.5 LSU/ha forage area

BUILDINGS

Dairy cows
- Housinf for all milking cows
- Milking system: fixed, with 20 places
- 2 milking periods (at 5:00 AM and 4:00 PM)

Other
- Slurry pond, with 940 m³
- Rainwater harvesting

DAIRY COWS NUTRITION

Forage (kg DM/cow/year): 6 374
- Grazed grass: 1 220
- Grass silage: 915
- Maize silage: 1 830

Concentrate (kg DM/cow/year): 2 409

INNOVATIONS TO DISCOVER

Fixed milking parlor versus mobile milking

Stables to spent the night versus 100% pasture

Animal welfare

AGRICULTURAL AREA

Total 100 ha Agricultural Area
- Permanent grassland: 30 ha
- Temporary grassland: 70 ha (50 with ryegrass silage)
- Maize silage: 43 ha
- Forage area/AA: 70%
- Permanent grassland/Forage area: 50%
- Feed self-sufficiency for forage: 100%

HIS TESTIMONY

Why did you join the Dairy 4 Future project?

" I have joined the project because I want to know how to increase the sustainability of my milk production. I want to know how to produce more with less."

Testimony:

Robert BRYSON (Northern Ireland)

Dairy 4 future

Interreg Atlantic Area

Robert Bryson
Northern Ireland
2019

PILOT FARM

INNOVATIONS TO DISCOVER

A low input, high output model, maximising milk from grass in a summer block calving system with minimal labour

THE DAIRY HERD

- Livestock Units (LSU) : 246
- Dairy cows – Breed: 192 Holstein
- LU dairy heifers: 59
- Calving period(s): June-October
- Age at first calving: 24 months

PRODUCTION

- Milk produced: 1 834 458 litres
- Milk sold: 1 774 018 litres
- % fat and protein content: 3.96 / 3.42
- Milk sold/cow/year: 9 554 litres
- Milk sold/ha forage area: 13 752 litres
- Stocking rate : 1.91 LSU/ha forage area

BUILDINGS

Dairy cows

- Cubicles with scraped passages
- Milking system: 2 x 20 units (x2 day)
- Silage blocks fed 3 times a week when housed
- Out of parlour feeding stations when housed

Heifers and calves

- Individual boxes 0-3 weeks
- Collective pens on straw bedding

DAIRY COWS NUTRITION

Forage (kg DM/cow/year):

- Grazed grass: 2 957
- Grass silage: 1 248

Concentrate (kg FM/cow/year): 2 643

AGRICULTURAL AREA

Total 129 ha Agricultural Area

- Permanent grassland: 64 ha
- Temporary grassland: 65 ha
- Grass silage (3 cuts): total 134 ha
- Total area can be grazed
- Low emission slurry spreading (100% slurry)
- Grazing grass measured and budgeted weekly
- Grass pre-mown before grazing (May-July)

HIS TESTIMONY

Why did you join the Dairy 4 Future project?

" In 2018 I became one of the 10 Dairy 4 Future farmers in Northern Ireland. The groupe was set up with the aim of increasing resilience, sustainability and competitiveness in dairy farmers in the Atlantic region of Europe. It allowed me to meet with like minded, progressive dairy farmers who wish to developp their business to become economically and environmentally sustainable. »

VIDEO

Testimony:

Rainton Farm (Scotland)

Dairy 4 future

Interreg Atlantic Area

Rainton Farm Scotland 2021

INNOVATIONS TO DISCOVER

Cow with calf
Ice cream & Cheese
Anaerobic Digestion Unit
Agroecological

THE DAIRY HERD

- Livestock Units (LSU) : 156
- Dairy cows – Breed: 115 Swedish Red, Montbéliarde and Holstein
- LU dairy heifers: 29
- Calving period(s): November to April
- Age at first calving: 24 months

ORGANIC PRODUCTION

- Milk produced: 387 338 litres
- % fat and protein content: 4.00 / 3.53
- Milk/cow/year: 3 368 litres (aiming 3 500 by 2023)
- Calving interval: 425 days
- Stocking rate : 1.2 LSU/ha dairy area

MANAGEMENT & HEALTH

Dairy cows
- Non rigid cubicles
- Milking system: tandem parlour (x1 day)
- Grazing up to 9 months per year

Dairy cow diet
- Grazed grass, grass silage, lucerne pellets

Cow with calf
- Calves separated overnight at 6-8 weeks
- Fully weaned at 5-6 months

Herd health
- Total use of antibiotics below RUMA target
- Low incidence of mastitis

CHALLENGES

- Lower volume of saleable milk
- Higher costs
- Finding a market for calves
- Lack of information on the CwithC system
- Need to adapt facilities to house cows & calves

LAND

- Permanent pasture: 200 ha
- Woodland and rough grazing: 140 ha
- Grazing area: 45 ha
- White & red clover: 35%
- No mineral fertilisers
- Single stage Anaerobic Digestion unit

HIS TESTIMONY

David & Wilma's comments on their innovative management system at Rainton Farm:

"While our cost of production even last year (2021) was well above conventional – 55ppl vs 34ppl – things have changed pretty dramatically with our COP falling to nearer 50ppl this year as conventional rockets to the high 40s. Making our counter-intuitive system appear much less of a luxury option…!"

• ESSENTIAL POINTS

- A network of 10 experimental farms, with three different dairy systems.
- The nitrogen balance is strongly linked to the level of intensification of the systems and in particular to the quantity of milk produced on the forage area.
- The most autonomous systems in term of protein have a major tendency to present the lowest levels o greenhouse gas emissions per litre of milk.

Research contributions to propose reference systems or improvement measures

Sylvain FORAY,
Dairy 4 Future Project Manager, Institut de l'Élevage (France)

TEN EXPERIMENTAL FARMS WERE INVOLVED IN THE DAIRY 4 FUTURE PROJECT. THEIR OBJECTIVE IS TO STUDY, TEST AND PROMOTE PRACTICES TO MEET THE ENVIRONMENTAL CHALLENGES FACING AGRICULTURAL PRODUCTION SYSTEMS: REDUCTION OF GREENHOUSE GAS EMISSIONS, PRESERVATION OF BIODIVERSITY, RECOVERY OF WATER QUALITY, PROTEIN AUTONOMY AND REDUCED DEPENDENCE ON FOSSIL FUELS.

THE 10 EXPERIMENTAL FARMS NETWORK: A LARGE VARIETY OF SITUATIONS

The 10 experimental farms are situated in Northern Ireland (CAFRE Dairy Herd), in Ireland (Solohead), in Scotland (Crichton Royal), in South West England (Duchy College), in Normandy (La Blanche Maison), in Brittany (Trévarez), in Pays de la Loire (Derval), in Nouvelle-Aquitaine (Lusignan), in Galicia (Mabegondo) and in Basque Country (Fraisoro) (Figure 26).

Study topics and publics

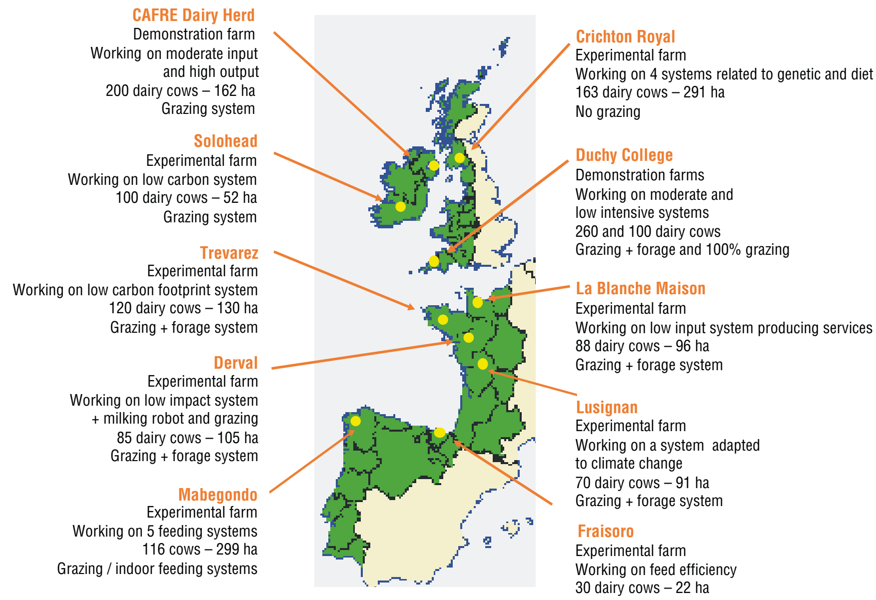
Each of the 10 farms has a specific orientation with technical and environmental efficiency as a keyword. Some farms work on a single dairy system that they seek to optimize, others work on the comparison of several systems or several breeding methods (comparison of diets, genetic potential, etc.).

Some of these farms are oriented towards the training of farmers, future farmers and advisors. Their research activities are more limited. These are the demonstration farms. The others host more advanced experiments but also participate in training activities. In consequence, the degree of optimisation of practices from an environmental point of view is variable according to sites and depending on the research themes being investigated.

• TO GO FURTHER

The characteristics of each of the 10 experimental farms involved in Dairy 4 Future project are presented in a sheet available on the project website (dairy4future.eu).

FIGURE 26:
MAP OF THE DAIRY 4 FUTURE EXPERIMENTAL FARMS NETWORK



Locations and climatic conditions

The altitude of the experimental farms varies from 40 to 250 m above sea level. The different sites benefit from a moderate oceanic climate, with mild temperatures, favourable to the growth of grass.
Annual rainfall fluctuates by a factor of two between the farms with 750 mm in Derval and 1429 mm in Fraisoro. The drainage water flow is overall high, more than 400 mm, except at Derval and Lusignan with around 250 mm (Table 12).
The texture of soils is mainly loamy texture with more or less clay.

TABLE 12: LOCATION AND CLIMATIC CONDITIONS OF THE 10 EXPERIMENTAL FARMS

Farm	COUNTRY	PARTNER	REGION	NB OF SYSTEM	ALTITUDE (M)	TEXTURE OF SOL	ANNUAL RAIN (MM)	DRAINAGE (MM)	T°C ((SPRING))
Greenmount	United Kingdom	CAFRE	Northern Ireland	1	50	Clay loam	900	400	12
Solohead	Ireland	Teagasc	Munster	1	95	Clay loam	1018	508	8.8
Crichton Royal	UK	SRUC	Scotland	4	1 to 75	Sandy loam	1199	327	12.7
Duchy College	UK	Duchy College	England	1	145	Clay loam	1375	700	8.6
La Blanche Maison	France	ASS. La Blanche Maison	Normandy	1	65	Loamy sandy clay	1022	459	14.1
Trévarez	France	CRAB	Brittany	1	75 to 250	Loamy clay	1195	547	11.2
Derval	France	CRAPL	Pays de la Loire	1	40	Loamy clay	750	250	11.1
Lusignan	France	INRAE	Nouvelle-Aquitaine	1	150	Loamy	797	250	10.8
Fraisoro	Spain	Neiker	Basque Country	1	147	Clay loam	1429	627	15.7
Mabegondo	Spain	Agacal	Galicia	5	94	Loamy	1126	178	13.7

THREE DIFFERENT DAIRY SYSTEMS STUDIED

As with the pilot farms, the farming systems found on these experimental and demonstration farms are generally representative of the systems found in their respective regions: grazing systems, housing systems or mixed systems (Table 13).


On the Lusignan experimental farm (Nouvelle-Aquitaine region).

©Inrae

Grazing systems: 4 experimental farms concerned

In this first group, we can identify the dairy systems of **Greenmount and Solohead** where the forage area in mainly constituted by grasslands and where the grazed grass represents more than 55% of the diet. The Greenmount farm works on a typical system in Northern Ireland where 88% of the forage area is grassland. The dairy cows produce around 8 775 litres of milk per year (11 123 litres per ha of forage area). The grasslands are pure perennial ryegrass and are fertilized with 168 kg of mineral nitrogen per ha. In the Low Carbon System of Solohead, the introduction of white clover in the grasslands is accompanied by no mineral fertilization. This system is based on low concentrate use (657 kg/cow/year) and the production per cow is moderate (5 805 l/cow/year) but the production per ha is more intensive with more than 15 000 litres/ha/year.

The experimental farm of **Lusignan** in France can be included in this category of grazing systems. This dairy system is based on diversification of fodder resources, maximisation of grazing (the grazed grass represents more than 50% of the diet), development of legumes and an adapted breeding strategy (2 calving periods, extension of lactation length to 16 months, three-way crossbreeding). This extensive system (5,300 litres of milk per ha) has a very low inputs dependency: only 309 kg of concentrates/cow/year and 11 kg of mineral nitrogen per ha.

Two of the five dairy systems tested in **Mabegondo** (Galicia) are grazing systems. The S4 system is based on red clover and hybrid ryegrass pasture and the S5 system on perennial ryegrass pasture. In the two systems, grazed grass represents respectively 60% and 66% of a dairy cows diet. When there is not enough grass in the pasture, the cows are fed with grass silage in the building. The forage ration is supplemented with concentrate and its characteristics depending on whether the cows consumed silage or pasture. The milk production per cow is quite the same between the 2 systems with 7 482 litres for the S4 system and 7 299 litres per cow per year for S5 system.

Mixed systems: 4 experimental farms concerned

This group is composed of the French experimental farms of **Derval, Trévarez** and **La Blanche Maison** where the forage area is composed of permanent and temporary grasslands and by maize silage. In Derval and Trévarez, the average annual ration is almost 60% maize silage and 40% grass. However, grazing is more important in Trévarez (31% of the ration) than in Derval (16%), due to the soil and climate conditions which are more favourable to grass growth in Trévarez. La

Blanche Maison drives a typical Normand breed system where grass represents 64% of the diet (half is grazed grass).
The 3 farms have in common a very low use of mineral fertilizer (< 35 kg N/ha of agricultural area) thanks to the white clover in association with perennial ryegrass and to the crop rotation combining grasslands, maize silage, and cereals.
Duchy College in Cornwall is also associated with a mixed system. Grazed grass represents 30% of the dairy cows forage intake, 50% of the ration is composed of conserved grass (silage) and the last 20% by maize silage. The use of concentrates is higher than in the French farms but the milk production is higher both per cow and per hectare.

Indoors systems: 3 experimental farms concerned

The indoor systems found in the experimental farms network are associated with specific trials.
The systems S1, S2 and S3 in **Mabegondo** are dedicated to indoor feeding and based on three typical forage systems. S1 is built on an Italian ryegrass in rotation with maize silage. The forage area of S2 is composed by hybrid ryegrass mixture with three legumes in rotation with maize silage. S3 is similar to S2, but silage maize is replaced with sorghum.
At **Crichton Royal,** in Scotland, the two contrasting systems which are currently being examined are High Energy (HE) and Standard Energy (SE) rations with 100% housing for lactating cows. The Holstein cows consuming each diet are of either high (Select) or moderate (Control) genetic merit, giving effectively four herds across the two diets.
Finally, the **Fraisoro** experimental farm in Basque Country works on feed efficiency, 100% of the of forage intake is constituted by grass silage or hay.

Many practices are identified in bovine production to reduce the GHG emissions and improve profitability. However, these individual practices are rarely integrated at whole system level. Monitoring of experimental dairy farming systems gives the opportunity to quantify the extent to which implementation of best practices will lower the carbon footprint, environmental impact maintaining current level profitability in contrasted pedoclimatic conditions.
The dairy systems and the dairy herd management set up on the experimental farms were based on structural

TABLE 13: GENERAL CHARACTERISTICS OF THE 10 EXPERIMENTAL FARMS INVOLVED IN DAIRY 4 FUTURE PROJECT

Farm and type of system	% FORAGE / AA	% GRASSLANDS / FA	MILK (L/ HA FA)	MILK (L/ COW)	FEED CONCENTRATES (KG/COW/YEAR)	% GRASS IN THE FORAGE DIET	% GRAZED GRASS IN THE DIET	FEED SELF-SUFFICIENCY FOR PROTEIN AUTONOMY (%)
Greenmount	100%	88%	11 123	8 775	2 843	84%	56%	63%
Solohead Low Carbon	100%	100%	15 366	5 805	657	100%	66%	88%
Crichton Royal C SE	100%	60%	16 178	8 988	2 847	70%	0%	37%
Crichton Royal S SE	100%	66%	17 576	9 436	3 013	70%	0%	35%
Crichton Royal C HE	100%	67%	32 427	8 991	4 782	68%	0%	22%
Crichton Royal S HE	100%	67%	32 479	11 279	4 782	68%	0%	28%
Duchy College	93%	84%	9 284	8 612	2 931	80%	30%	53%
La Blanche Maison	98%	82%	8 009	6 565	1 335	64%	36%	67%
Trévarez	92%	68%	8 377	7 822	702	39%	31%	78%
Derval	86%	63%	7 679	8 276	1 367	38%	16%	62%
Lusignan	93%	70%	5 267	6 335	309	81%	52%	94%
Fraisoro	100%	100%	14 072	6 809	3 687	100%	0%	27%
Mabegondo S1	100%	0%	/	8 039	1 578	54%	0%	51%
Mabegondo S2	100%	0%	/	8 696	1 389	54%	0%	59%
Mabegondo S3	100%	0%	/	7 808	1 377	56%	0%	57%
Mabegondo S4	100%	100%	/	7 482	1 367	100%	66%	83%
Mabegondo S5	100%	100%	/	7 299	1 330	100%	70%	84%

choices linked to research questions, questions about their viability, and professional orientations.
The various practices tested are based on reducing the turnover rate and calving age of heifers, reducing feed inputs, optimising the place of grasslands in rotations, the interest of legumes in association grasslands, genetics, and the use of manure produced on the farm to limit the use of mineral fertilisers and to encourage the return of organic matter to the soil.
French CAP'2ER® tool was used to determine the GHG gross emissions and the nitrogen balance, in the seventeen dairy systems found on the ten experimental farms. The GHG emissions were measured using IPCC methodology, and life cycle assessment. Carbon storage is not presented in this document.

NITROGEN BALANCE: SOLUTIONS TO REDUCE IT

The nitrogen balance on the experimental farms varies from 56 to 675 kg N/ha of arable area (AA). This value is higher in the indoor systems than in the grazing or mixed systems (Table 14). It's mainly due to the use of inputs like concentrates or fertilizer. The nitrogen balance is strongly linked to the level of intensification of the systems and in particular with the quantity of milk produced on the forage area (R^2 = 0,79).

The 2 "High Energy" systems at Crichton Royal requires high quantity of concentrates. They produce the highest quantity of milk per ha, but also the highest nitrogen surplus. What is interesting is that the system based on cows with "Selected" genetic merit appears to have lower nitrogen surplus and a highest nitrogen use efficiency. It is important to note that the areas associated with the 4 systems are very small and do not reflect a reality. This implies very large and probably overestimated nitrogen surpluses.

TABLE 14: NITROGEN BALANCE AND NITROGEN USE EFFICIENCY, ON THE 17 EXPERIMENTAL SYSTEMS STUDIED IN DAIRY 4 FUTURE PROJECT

	N INPUTS (KG N/HA AA)						
Farm	CONCENTRATES	FERTILIZER	SYMBIOTIC FIXATION	TOTAL	N OUTPUTS (KG N/HA AA)	N BALANCE (KG N/HA AA)	N EFFICIENCY (%)
Greenmount	105	73	0	282	71	211	25%
Solohead Low Carbon	51	0	121	181	95	86	52%
Crichton Royal C SE	276	70	39	431	90	341	21%
Crichton Royal S SE	309	73	34	459	107	352	23%
Crichton Royal C HE	693	74	41	901	185	716	21%
Crichton Royal S HE	564	74	45	777	195	582	25%
Duchy College	104	178	59	355	65	290	18%
La Blanche Maison	65	34	39	158	57	101	35%
Trévarez	39	28	32	115	53	62	47%
Derval	68	32	27	188	92	96	47%
Lusignan	6	11	65	94	37	56	41%
Fraisoro	193	73	0	315	77	238	24%
Mabegondo S1	147	174	0	331	68	263	21%
Mabegodno S2	124	85	0	219	74	145	34%
Mabegondo S3	124	65	0	199	68	131	34%
Mabegondo S4	44	0	190	243	65	178	27%
Mabegondo S5	40	101	0	151	70	81	46%

On the Crichton Royal experimental farm (Scotland).

The 3 indoors systems of Mabegondo S1, S2, S3 produce more than 12 500 litres of milk per forage area. S1 and S2 produce quite the same quantity of milk per ha but the introduction of legumes in association with Hybrid ryegrass in the winter crop allows a reduction in the use of concentrates and fertilizer compared to S1 (winter crop = pure Italian rye grass). In consequence, the nitrogen surplus is reduced by 45%.

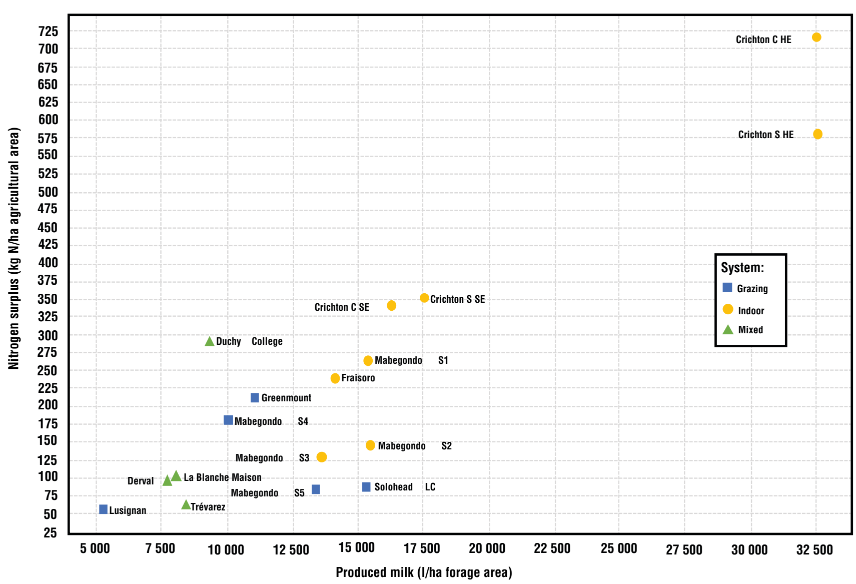
Different kind of grazing systems are found. At Solohead, the milk production per ha is the highest compared to the other grazing systems. Its inputs are only related to symbiotic fixation and concentrates. They represent respectively 67% and 33% of nitrogen inputs. The nitrogen balance is lower than 90 kg N/ha.

The grazing system at Greenmount requires more concentrates and fertilizer than in Solohead, mainly because this farm works with pure perennial ryegrass in the grasslands. Its nitrogen surplus is higher.

Lusignan is an extensive and low input system, producing less than 5 300 litres of milk per ha. Symbiotic fixation represents 70% of the nitrogen inputs.

The mixed systems, mainly found in France, have a nitrogen surplus close to 100 kg N/ha (La Blanche Maison) or lower (Derval and Trévarez). They are mainly characterized by a low consumption of fertilizer (less than 35 kg N/ha). Crops in rotation with temporary grasslands (perennial ryegrass and white clover) require less nitrogen. The quality of the forage allows also to limit the use of concentrates.

FIGURE 27: RELATION BETWEEN DAIRY PRODUCTION PER HECTARE AND N SURPLUS (KG N/HA) ON DAIRY 4 FUTURE EXPERIMENTAL FARM SITES



GREENHOUSE GAS EMISSIONS: IS THE SOLUTION IN THE PROTEINS?

As shown by the Table 15, the gross GHG emissions are quite similar between the 17 farming systems when expressed per litre of fat and protein corrected milk (FPCM). This difference is more pronounced when these emissions are expressed per ha of arable area (AA).
It is interesting to note that the share of GHG emissions linked to inputs (concentrates, fertilisers, fossil energy, etc.) is more marked in building systems (Figure 28).
The search for a lower dependence on purchased proteins is thus a relevant solution as shown by the Figure 29 (R^2 = 0,71). The most autonomous systems in terms of protein have a major tendency to present the lowest levels of GHG emissions per litre of milk. This trend is real between systems but also within different types of systems.

TABLE 15: GREENHOUSE GAS EMISSIONS ON THE 17 EXPERIMENTAL, ON THE 17 EXPERIMENTAL SYSTEMS STUDIED IN DAIRY 4 FUTURE PROJECT

Farm	GHG EMISSIONS (KG EQ CO2/L OF FPCM)	GHG EMISSIONS (KG EQ CO2/HA AA)	INPUTS EMISSION / TOTAL EMISSION (%)
Greenmount	1.01	14 695	27%
Solohead Low Carbon	0.75	15 015	7%
Crichton Royal C SE	1.24	24 683	24%
Crichton Royal S SE	1.12	25 126	26%
Crichton Royal C HE	1.28	47 720	32%
Crichton Royal S HE	1.08	42 432	29%
Duchy College	1.12	11 962	29%
La Blanche Maison	0.98	9 192	18%
Trévarez	0.84	8 078	15%
Derval	0.92	8 057	18%
Lusignan	0.90	5 786	13%
Fraisoro	1.10	18 364	33%
Mabegondo S1	0.80	15 622	27%
Mabegondo S2	0.75	14 119	21%
Mabegondo S3	0.80	13 427	23%
Mabegondo S4	0.81	9 622	11%
Mabegondo S5	0.81	13 847	18%

FIGURE 28: SHARE OF INDIRECT EMISSIONS PER TYPE OF SYSTEMS IN THE EXPERIMENTAL FARMS INVOLVED IN DAIRY 4 FUTURE PROJECT

Indirect emissions, related to the manufacture and transport of inputs, are more pronounced in indoor system.

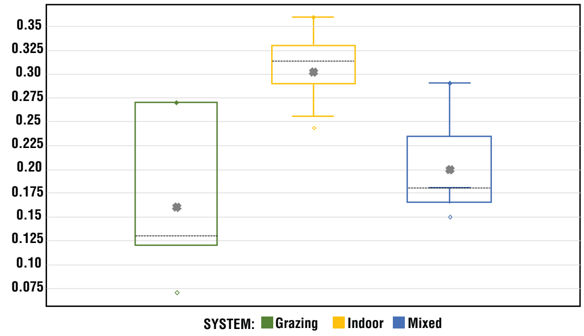
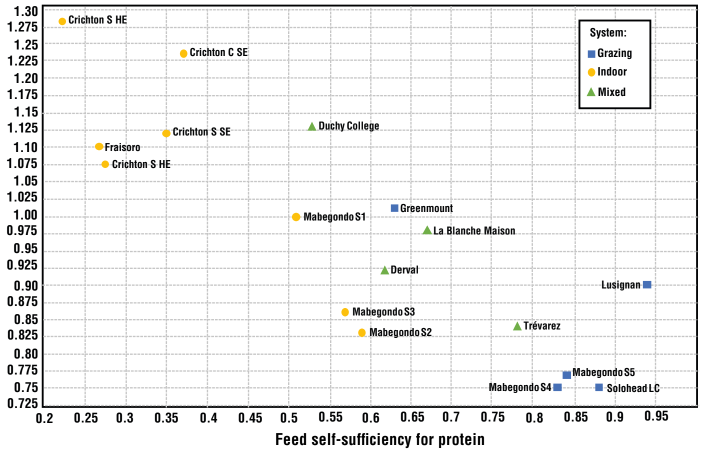


FIGURE 29: FEED SELF-SUFFICIENCY FOR PROTEIN AND GHG EMISSIONS FOR THE EXPERIMENTAL FARMS INVOLVED IN DAIRY 4 FUTURE PROJECT

The most autonomous systems in terms of protein have a major tendency to present the lowest levels of GHG emissions per litre of milk.



« By activating several levers such as the suppression of energy concentrates (cereals), the exclusive use of rapeseed cake, etc., Trévarez experimental farm has shown that all dairy farms in Brittany can also reduce their impact on climate change. »

• ZOOM ON…

HIGHLIGHT OF THE WORK DONE ON THE TRÉVAREZ EXPERIMENTAL FARM IN BRITTANY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For several years now, the priority has been to use the resources available on the farm as efficiently as possible and **to limit the use of inputs,** which have significant «environmental costs», particularly in terms of the GHG emissions linked to their manufacture and transport. The low-carbon system of Trévarez is **not dependent on external forage purchases.** In 2021, the dairy system was **78% self-sufficient in protein.** Forage intake is 6,200 kg DM per cow (excluding concentrates), of which 49% is maize. **Grazing represents 77% of the grass consumed** by the cows. To produce 7,677 litres of milk/year, the dairy cows can count on quality forage, particularly in terms of the grass harvested, allowing **only 690 kg of rapeseed cake per animal** to be distributed over the year, i.e. **89 g per litre of milk.** This limited quantity of protein concentrates, which is not associated with a change in land use (deforestation), is synonym of a low «indirect» environmental impact. In addition, the fertilization of crops and grasslands is essentially ensured by the manure produced on the farm. With the rotations in place, leaving a large place for temporary grasslands (perennial rye grass + white clover), **the use of mineral fertilizers is less than 35 kg of nitrogen per ha of UAA.**
Better growth of heifers between birth and insemination and the choice of conserved heifers for renewal have permitted to **reduce the calving age of heifers** in 2021 by 2 months compared to other years (27 to 25.1).

All of these practices have resulted in an 18% reduction in GHG emissions per litre of milk.

TABLE 16: TRENDS IN GHG EMISSION, PROTEIN SELF-SUFFICIENCY, USE OF CONCENTRATES AND FERTILIZER IN TRÉVAREZ AND COMPARISON WITH REGIONAL REFERENCES

	TRÉVAREZ YEAR 2021	TRÉVAREZ YEAR 2015	REGIONAL REFERENCES
GHG emission (kg eq CO2/l of milk)	0.83	1.01	1.02
Protein self-sufficiency (%)	78	68	67
Concentrates (kg/dairy cow)	690	965	1 148
Concentrates (g/l of milk)	89	122	148
Mineral fertilizer (kg N/ha AA)	34	26	46


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CONCLUSION

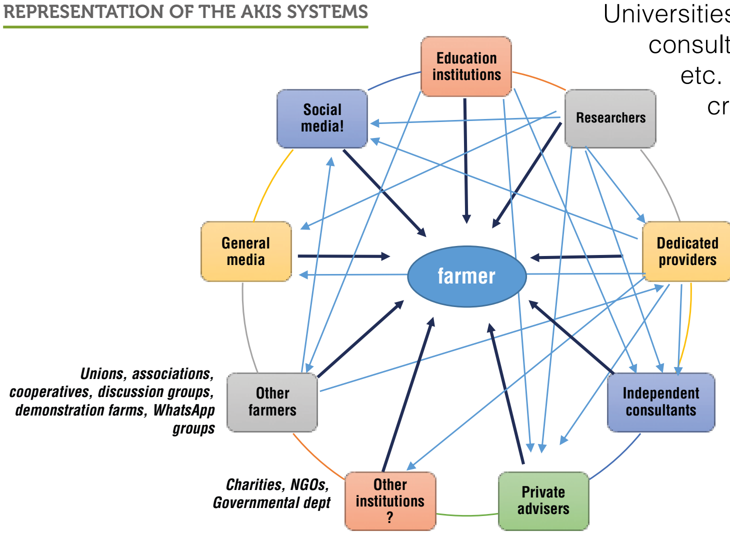
Martina DORIGO,
Senior Dairy Scientist, AHDB (United Kingdom)

How to improve the dissemination and sharing of information.

New knowledge and innovation have always supported the evolution of agriculture, especially since the second World War, when agriculture was a key sector, and its objectives were to increase the food supply to the population and to secure income for farmers. In the dairy sector, the use of new knowledge and innovation has allowed a better productivity in the last decades, and is now critical to improve resilience, competitiveness, and sustainability, which are the core of the Dairy 4 Future project.

Dissemination of any newly created knowledge and innovation is necessary to a successful uptake: the AKIS (Agricultural Knowledge and Innovation Systems) concept helps to understand better the generation and dissemination process, describing the organisations and individuals involved and the complex interactions among them.

FIGURE 30:
REPRESENTATION OF THE AKIS SYSTEMS



Universities, research centres, training organisations, consultants, supply chains, farmers' organisations etc. are all AKIS players engaged in the task of creating, communicating, and putting into practice innovative solutions for the dairy sector (Figure 30). Farmers are always the natural end users of these innovations, but they also play a critical role in creating and disseminating knowledge and innovation themselves.

Whilst the AKIS have historically developed differently across the Atlantic area, with different levels of integration and strength, the common theme across countries is the continuous adaptation of the AKIS to the challenges faced by dairy farming: as such, they share common strengths and weaknesses, which have been highlighted in the Dairy 4 Future project by appointed experts in each country/ region (Figure 31).

What are the main actions to increase the AKIS' effectiveness in connecting science and practice and foster innovation? The 2019 EU SCAR Report "Preparing for Future AKIS in Europe" has identified four main actions for successful AKIS strategies:

- Enhancing knowledge flows and strengthening links between research and practice to support broad availability of independent advice and to maintain the researchers' motivation through a more collaborative work with the other AKIS players;
- Strengthening all farm advisory services and fostering their interconnection within the AKIS, allowing those closest to the farmers to easily access and transfer the latest knowledge and innovation, ideally by involving them in several stages of the projects;
- Enhancing cross-thematic and cross-border interactive innovation, to help access and develop new ideas and innovations;
- Supporting the digital transition in agriculture.

Other suggestions coming from the Dairy 4 Future experts are listed by Figure 32.

Resilience, competitiveness, and sustainability will become increasingly important in the future years to ensure a thriving dairy farming sector: a strong, adaptable and innovative AKIS will be key to achieve these objectives.

FIGURE 31: SWOT ANALYSIS OF THE AKIS IN THE ATLANTIC AREA

Strengths	Weaknesses	Opportunities	Threats
•Open mindedness, focus, interest in tech and innovation •Diversity of available advice and expertise •Embedded and bespoke advice •Availability of free advice •Innovative centres and networks •Motivation •Forward thinking mindset	•Low spending and insufficient resources •Low collaboration among AKIS players •Difficult knowledge delivery in remote areas •Long time to generate results •Fragmentation and low relevance of advice, wich is often siloed or not specific enough •Lack of generational turnover •Lack of shared vision, scope and mission •Bureaucracy	•Young generations of farmers and advisers with strong motivation and passion •Increasing availability of different delivery methods for learning and transfer knowledge •Future needs for capable and adaptive workforce •Increasing focus on sustainability and environment •Evolving requests from consumers •Political opportunities	•Reduction of public funding and higher reliance on private not independent advice •Risk of duplication/overlapping, research unfocused on end-user needs and lower quality of knowledge transfer •Loss of confidence in the main AKIS •Change in the farming industry (i.e. shortage of skill labour) •Requirement from consumers •Political uncertainties

FIGURE 32: DAIRY 4 FUTURE SUGGESTIONS TO INCREASE THE AKIS EFFECTIVENESS

- Collaboration and integration among AKIS. Co-design of projects with farmers to make the most of the « tacit knowledge »
- Effective training of farmers and advisors to ensure a capable and adaptive workforce. Inclusion of transferable skills
- Creation of learning networks such as LINSA (Learning Innovation Networks for Sustainable Agriculture) connected with the AKIS
- Identification and prioritisation of the win-wins in knowledge and innovation, maintaining enough flexibility
- Promotion off cross-region exchange visits among farmers including technicians, if possible, policy makers
- Identification of « flagship » farms to showcase best practice and innovation
- Increased use of online tools and learning methods
- More individualized advisory system, with focus on the goals and objectives of young farmers, and use of up-to-date decision support tools and technology
- Appropriate consideration of consumers requests to increase social acceptance
- Exploitation of the circle of trust (« influencing the influencer ») to enhance the effectiveness of message delivery and uptake

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Many thanks to all the farmers, engineers, advisors, researchers and other partners from the different regions involved in the Dairy 4 Future project.

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Design and realization: Beta Pictoris • N° ref Idele: 0022 304 008 • ISBN: 978-2-7148-0230-9 • September 2022

The partners of Dairy 4 Future Interreg Atlantic Area project

The Dairy 4 Future project is led by the Institut de l'Élevage, with a consortium of 10 other partners: Scotland's Rural College - SRUC (Scotland), College of Agriculture, food and Rural enterprise - CAFRE (Northern Ireland), Agriculture and Horticulture Development Board - AHDB (Wales and South West England), Teagasc (Ireland), Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement - INRAE (France), the Chambre d'agriculture de Bretagne - CRAB (France), Neiker (Basque Country, Spain), Axencia Galega Da Calidade Alimentaria - AGACAL (Galicia, Spain), Universidade de Tras-os-Montes e Alto Douro - UTAD (Northern Portugal), Institut Superior de Agronomia – Universidade de Lisboa - ISA (Central Portugal and Azores).

The project also involves some 20 economic operators (mainly dairy groups) including:

Sodiaal, Savencia and Innoval for France
Glanbia, Carberry, LacPatrick and Ulster Farmers Union for Ireland
Lac Patrick, Trewithen Dairy and Lactalis Scotland for United Kingdom
Iparlat, Lursail, Cooperativa Agraria Provincial de A Coruñaand FEIRACO for Spain
Associação Agrícola de São Miguel (Azores), Associação Agrícola da ilha Terceira (Azores), AGROS, União das Cooperativas de Produtores de Leite de Entre Douro e Minho e Trás-os-Montes and Associação Portuguesa de Criadores da Raça Frísia for Portugal.

All the results of the Dairy 4 Future project are available on the official website:

dairy4future.eu

and on the social networks

FOR MORE RESILIENT DAIRY FARMING IN THE ATLANTIC AREA
Lessons from Dairy 4 Future project

The Atlantic area has many territorial assets for dairy production: ideal soil and climatic conditions, landscape, infrastructure and processing capacity, large and skilled agricultural population, supported by efficient research and innovation organizations.

Milk production in this area is oriented to dairy commodities and ingredients for export and subject to price volatility. Furthermore, the COP21 sets out to mitigate emissions of greenhouse gases, while forage and grass production is being affected by climate change.
From Scotland to the Azores, the Dairy 4 Future project aimed to increase the competitiveness, sustainability, and resilience of dairy farms in the Atlantic area. Its objective was to identify, evaluate and then propagate innovative practices to European dairy advisors and farmers through transnational seminars or farm open days, publications, videos, or training tools.
The project put innovative farmers at the center of practice-based research work and combined several methods to adapt and develop scientific knowledge, which will lead to technical solutions and recommendations to be shared across the network.

«Since the beginning of the Dairy4Future project, our group of French pilot farmers has had the opportunity to meet on several occasions to discover or learn more about the dairy sector in the different regions of the Atlantic Area. Our meetings allowed us to visit our respective farms, present our breeding systems, and share our work methods, and even to transfer or test practices on our respective farms. We visited the french experimental farms involved in the project, discuss the trials conducted and most importantly present our expectations and needs. We were also delighted to travel to Ireland in June 2022 to visit the pastures of our Irish colleagues!" Jean-Pierre Morille – Dairy farmer in Pays de la Loire, France

LES DOSSIERS TECHNIQUES DE L'ÉLEVAGE : UN REGARD ÉCLAIRANT SUR DES SUJETS PHARES

L'Institut de l'Élevage présente le sixième numéro des DOSSIERS TECHNIQUES DE L'ÉLEVAGE.

Cette collection a pour ambition d'apporter, à chacune de ses parutions, un regard nouveau et perspicace sur un sujet technique d'actualité ou clé pour les éleveurs et leurs filières. Y sont présentés les derniers résultats des études conduites par l'Institut de l'Élevage et ses partenaires, sur des sujets portant sur les techniques d'élevage, les structures des exploitations, les bâtiments et équipements d'élevage, les enjeux sociétaux (environnement, bien-être animal), la qualité des produits, le travail en élevage, les transformations des métiers de l'agriculture ou les relations entre acteurs des filières et des territoires… Ces dossiers mettent tout particulièrement l'accent sur les analyses critiques, les avis d'experts et les approches prospectives. L'objectif est de nourrir la réflexion stratégique des acteurs des filières herbivores.

Ce numéro 6 des DOSSIERS TECHNIQUES DE L'ÉLEVAGE présente les principaux résultats du projet interreg Atlantic Area Dairy 4 Future - Propagating innovations for more resilient dairy farming in the Atlantic area.

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