

# Grassland and forages in high output dairy farming systems in Flanders and the Netherlands

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## Abstract

The dairy sector in the EU faces many challenges as a consequence of political, economic and societal developments. Many countries are responding to these changes by exploring the possibilities and constraints of scaling up and intensification. This also holds for Flanders and the Netherlands, where dairy farming systems are already intensive. This paper describes high output dairy farming systems in the Netherlands and Flanders and discusses their problems, solutions and perspectives associated with grassland and forages. The dairy farming systems are generally characterised by high fluxes of nitrogen and phosphorus through the systems. Research has led to a strong decrease in mineral losses to the environment in practice. The decrease in grazing is another concern of high output systems. Many activities have been initiated with the aim of stabilisation of the number of dairy cows grazing. Further scaling up of farms and intensification is thought to be possible in the Netherlands and Flanders because of high soil fertility, favourable weather conditions, a good infrastructure and well-educated farmers.

**Keywords:** Flanders, the Netherlands, high output systems

## Introduction

Agriculture worldwide is facing multiple challenges. The most striking challenge is presented by the need to feed the increasing world population (FAO predicts a global population of 9 billion by 2050). Moreover, changing consumption patterns result in an increasing demand for animal proteins (e.g. FAO, 2006). More food must be produced and this has to be done in a sustainable way within the limits of our planet earth. Global resources like land, water and nutrients are scarce. Dairy farming systems contribute to the production of food and especially to the production of animal proteins. The European dairy sector is well equipped to produce animal proteins, and in many situations grass-based livestock systems have the capacity to produce these animal proteins from resources (grass, forages) that cannot otherwise be converted into food. The European dairy sector is also facing challenges like increased losses (nutrients, greenhouse gases) to the environment (soil, water, air), abandonment of rural areas and biodiversity losses. Vast areas of grasslands are not utilised. Importing feed from outside Europe leads to environmental problems in other parts of the world. National and European legislation (e.g. Nitrate Directive, Water Framework) aims to protect the environment but, at the same time, leads to restrictions for the dairy sector. In addition, societal demands have to be met, for example with respect to grazing, landscape, animal welfare and the use of antibiotics. The dairy sector responded in the past to these political, economic and societal challenges by scaling up and intensification. As a result of the abolition of the European milk quota in April 2015, further scaling up and intensification of the dairy sector are expected, especially in regions which currently already have a high production. The aim of this

paper is to describe the high output dairy farming systems in such a region, namely in the Netherlands and in Flanders, and to discuss the possibilities and constraints of grassland and forages in these systems.

## **Definition of high output dairy systems**

When discussing high output dairy systems there are a few important points to consider. Firstly, 'high output' is a relative concept based on comparing systems and comparing their outputs that can vary in space and time. Outputs differ from one European region to another. Farms that were classified as 'high output' two decades ago may be mainstream at present. The general global trend in agriculture is an increase in output due to intensification to meet the growing global food demand.

Secondly, the unit of high output should be considered. The numerator is relatively easy to define. In the dairy sector the numerator of output is usually milk (kg milk or kg milk solids). The denominator, however, can be defined at multiple scales, e.g. high output per dairy cow, per ha of land, per farm, per labour unit, per region or per country. There is a further complication, that the output of dairy systems can be defined on a per-year basis and also per cow lifetime. In the latter case, dairy cows with a long lifetime may have a higher output. They may even have a higher average annual output, since the effect of the first non-productive years can be spread over a larger number of years.

Finally, it should be noted that output and input are usually related: the higher the input (e.g. fertilisation, animal feed), the higher the output. Increasing the input may lead to ecological problems, which is an undesirable development. Therefore, the concept of 'sustainable intensification' has been introduced (e.g. The Royal Society, 2009; Godfray *et al.*, 2010). Sustainable intensification of dairy production systems is intensification in profitable animal production systems, where yields are improved without damaging ecosystems, animal integrity and consumers concerns. This leads to eco-efficient farms with maximum output, minimum use of resources and minimum effect on the environment.

## **Dairy farming systems in Flanders and the Netherlands: developments and characteristics**

At present dairy farms in Flanders and the Netherlands are usually specialised, i.e. their main activity is dairy production. In the Netherlands, forage production and grassland management have undergone substantial changes over the last 50 years (Van Dijk *et al.*, 2015). Yields, quality and utilisation of crops increased due to improved grassland management, fertilisation and breeding. The average number of dairy cows per farm increased tenfold to about 85, average milk production per cow doubled to somewhat more than 8,000 kg milk cow<sup>-1</sup>, average milk production per ha tripled to about 15,000 kg ha<sup>-1</sup> and the number of dairy farms declined tenfold to about 18,000 (Van Dijk *et al.*, 2015; CBS, 2015).

In Flanders, similar increases in farm size and production can be seen. Throughout Flanders, 78 farms with high economic profits per cow were followed during a period of 10 years (2003-2013), during which the average number of cows per farm increased from 64 to 77 and the milk production per cow increased from 7,400 to 8,000 kg milk cow<sup>-1</sup>. On average, the grassland area increased from 21.0 to 22.6 ha, the maize area from 17.2 to 20.9 ha and the area for other forages from 1.3 ha to 1.4 ha, leading to an average increase of more than 5 ha per farm in this period. The average milk production per ha of those 78 farms increased from 17,000 to 19,400 kg milk ha<sup>-1</sup>.

The developments in milk production per cow and numbers of dairy cattle is shown in Figure 1 at the national level for the Netherlands. Until spring 2015, the EU milk quota system limited the maximum amount of milk produced per country. The total number of dairy cows decreased following the introduction of the milk quota system in 1984 and the average milk production per cow increased. A similar development was seen in Flanders.

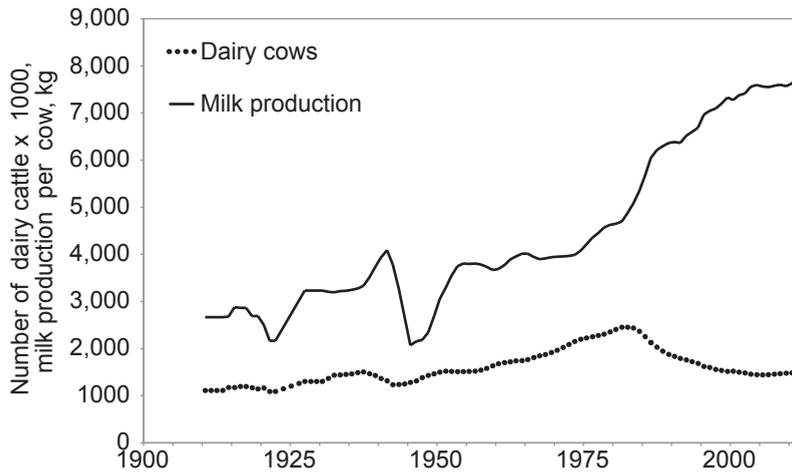


Figure 1. Changes in number of dairy cows and in milk production per dairy cow in the Netherlands from 1910 to 2011 (data CBS, modified).

## Soils

Even in relatively small land areas, such as Flanders and the Netherlands, large regional differences in soil quality exist. Soil formation is strongly influenced by the North Sea and the rivers Scheldt, Rhine and Meuse that flow through these regions, and also by climate and human intervention. Flanders is almost completely situated above sea level, whereas approximately 60% of the Netherlands is situated below sea level (-1 to -7 meter) and protected by dykes, dams and dunes. Clay soils are mainly found near the sea, near the rivers and in the areas that were reclaimed from the sea. Peaty soils are found in the western and northern parts of the Netherlands. Sandy soils are mainly situated in higher parts of the Netherlands which are above sea level in the east and the south of the country. The Soil Map of Flanders shows that along the North Sea coast and the North West of Flanders the soil texture is mainly clay, whereas the central and most extensive area is sandy, becoming more loamy in the south of Flanders.

The regional differences in soil type are reflected in regional differences in soil quality. Part of this fertility was inherited from the sea and the river deltas, part is man-made (by e.g. manure applications). The soils in the eastern and southern part of the Netherlands and in Flanders were originally mostly poor sandy soils. Current fertility status of soil organic matter content and soil P content in Flanders and the Netherlands is shown in Figure 2. The peaty (marine) soils in the West and the North of the Netherlands can be recognised as areas with a relatively high soil organic matter content. Soil P content is generally high.

## Grass yield and grass quality

The temperate maritime climate influenced by the North Sea and the Atlantic Ocean leads to cool summers and moderate winters. Daytime temperatures vary from 2-6°C in winter and 17-20°C in summer. The annual rainfall of 700-800 mm is evenly distributed over the year. These are good conditions for abundant grass growth in the growing season (April – October). Gross yields of 16-18 tonnes dry matter (DM) yr<sup>-1</sup> are no exception. However, the gross yield (i.e. the grass yield that is grown on the field) is less important than the net yield (i.e. the herbage that is either taken up by the dairy cow or mechanically transported from the field). For determination of net yield, the grazing losses and harvesting losses should be deducted from the gross yield. Grass yield and grass quality in Flanders are in the same order of magnitude as in the Netherlands. Aarts *et al.* (2005) estimated the net yield of grasslands in the Netherlands and calculated an average of 10.4 tonnes DM yr<sup>-1</sup> (9.6 for peaty soils, 10.3 for clay soils, 10.4 for wet sandy soils and 11.5 for dry sandy soils). Variation among farms is large.

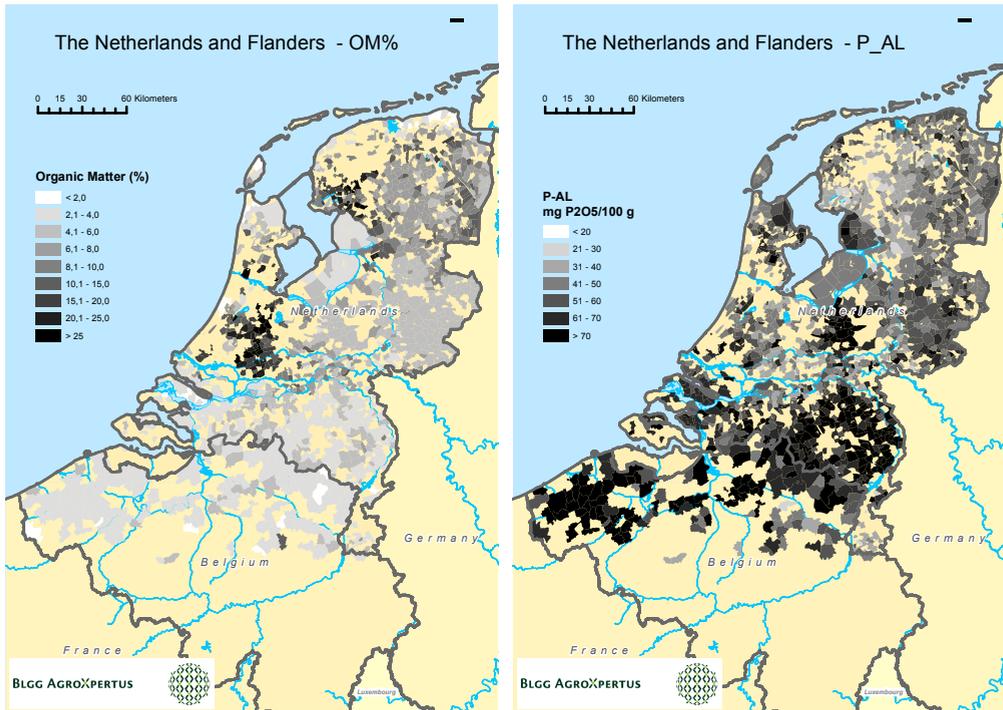


Figure 2. Examples of soil quality in Flanders and the Netherlands: a) soil organic matter content (%), and b) P content, P-AL, mg  $P_2O_5$  / 100 g. Source: Blgg AgroXpertus, average of >70,000 samples in the Netherlands and approximately 5,000 samples in Flanders.

Trends in average grass quality during a period of 15 years in the Netherlands are shown in Table 1. Crude protein content and crude ash concentrations of grass decreased during the last years; those of K decreased and Se increased. The decrease coincided with a decreased fertiliser application. The increase in Se content can be explained by the increased use of Se-containing fertilizers (Reijneveld *et al.*, 2014; Abbink *et al.*, 2015).

Table 1. Median values and mean annual change (indicated by slope *b*) of grass quality; grass samples taken from grass silage in the Netherlands. The regression coefficient indicates the mean change of herbage quality per year for the period 1996 – 2009 (Reijneveld *et al.*, 2014).

Herbage characteristics <sup>a</sup>	Median	Slope <i>b</i>	<i>R</i> <sup>2</sup>
Dry matter	435	n.s.	n.s.
Crude protein	165	-2.43**	0.52
Crude fibre	242	n.s.	n.s.
Crude ash	101	-2.53**	0.69
S	3.0	n.s.	n.s.
P	4.0	n.s.	n.s.
K	35	-0.30*	0.32
Mg	2.4	n.s.	n.s.
Ca	4.7	n.s.	n.s.
Na	2.5	n.s.	n.s.
Se	52	8.33**	0.51

<sup>a</sup> DM in g kg<sup>-1</sup>, SE in mg kg DM<sup>-1</sup>, all other in g kg DM<sup>-1</sup>

\*  $P < 0.05$ , \*\*  $P < 0.01$ , n.s. = not significant

## Rations

Dairy cattle rations in Flanders and the Netherlands are in general characterised by relatively large amounts of supplementation, mainly maize silage, grass silage and concentrates. The distribution of silage maize over Flanders (Figure 3) shows many areas where a lot of silage maize is produced. Farms in those areas usually supplement more silage maize than farms in areas where not a lot of maize is produced. This is also true for the Netherlands.

An example of the development of rations on dairy farms in Flanders over the last 10 years is given in Table 2. The amount of grazed grass has been estimated using the known intake and the calculated needs of the dairy cows. DM intake from grass in Flanders has remained relatively stable throughout the years, but the DM intake from grass silage has increased at the expense of grazed grass. This is partly explained by the fact that the herd size of the dairy farms has increased while the area around the farm that could be grazed has not increased to the same extent. A similar development was seen in the Netherlands.

## Nutrient losses

High output dairy farming systems in Flanders and the Netherlands are generally characterised by high fluxes of nitrogen (N) and phosphorus (P) through the systems. These elements cycle through the system by transfer between the components of the farm, i.e. from crops/feed to the herd, from the herd to manure, from manure to soil and from soil to crops/feed. Inadequate nutrient management of these intensive nutrient flows may cause high losses to the environment, which puts the quality of water, air and nature under pressure. Moreover, it reduces resource-use efficiency because not only exports as milk

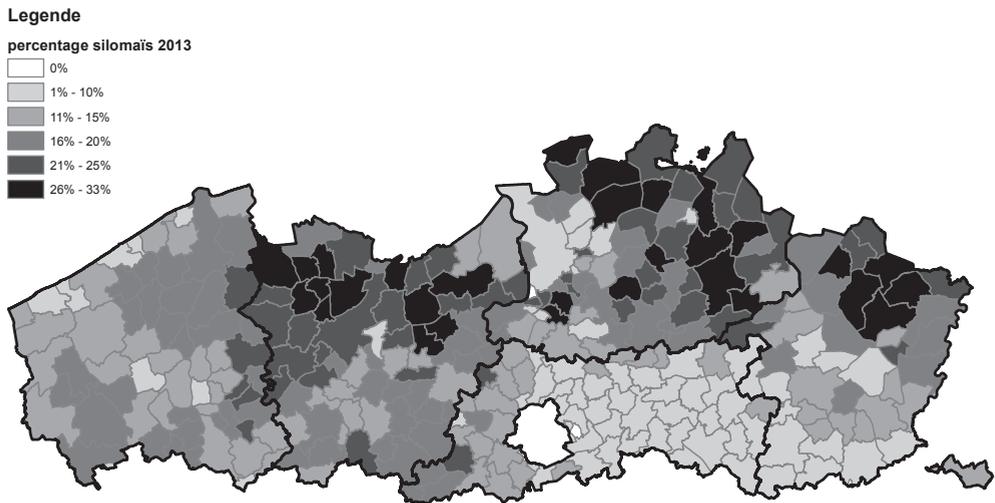


Figure 3. Distribution of silage maize in Flanders (% of total land area). Source: Landbouwcentrum Voedergewassen.

Table 2. Development of rations in Flanders during the period May-September (kg DM cow<sup>-1</sup> day<sup>-1</sup>); average of the 20% most productive farms in the data set of farm accounting by the Belgian Farmers Union.

	2003/2004	2008/2009	2013/2014
Grazed grass	7.03	4.33	3.60
Grass silage	1.34	3.37	3.40
Maize silage	7.32	7.70	8.21
Other	3.87	4.45	3.89

and meat but also losses from the systems are replenished by purchased feeds and fertilisers. From the mid-1980s onwards, an efficient use of fertilisers with minimal losses to the environment was promoted and research efforts were dedicated in that direction.

The experimental farm De Marke was set up with the aim to explore and demonstrate the possibilities to produce milk at an intensity of 12,000 kg milk ha<sup>-1</sup> without violating strict environmental standards (Aarts *et al.*, 1992). Optimized mineral management on the pre-designed farming system resulted in a strong reduction of N and P surpluses compared to common practice (Aarts *et al.*, 2000). In the various management systems that were explored since 1993, N surpluses at farm level amounted to 98-165 kg ha<sup>-1</sup>. P surpluses ranged from 0-6 kg ha<sup>-1</sup> (Verloop, 2013). In the project 'Cows & Opportunities' the research on improvement of nutrient management was extended to commercial dairy farms on various soil types (Oenema, 2013).

In Flanders research was carried out to avoid losses to the environment and to increase the production efficiency at the ILVO experimental farm and at the Policy Centre for Sustainable Agriculture (Nevens *et al.* 2006; Meul, 2008). The Policy Centre identified top farms within a large set of monitored dairy farms and used the dataset to develop a monitoring and management tool to improve the eco-efficiency and sustainability in Flemish dairy farms (Meul *et al.*, 2009). Mineral balances at farm level were studied in the period 1987-1998 as a tool for efficient farm management: reducing NPK losses and improving financial output (Carlier *et al.*, 1992, Michiels *et al.*, 1998; Dessein and Nevens, 2007). Reduction of N losses as well as efficient N fertilisation is important for a better environment and sustainable use of N as a production factor (Nevens and Reheul, 1998).

The research has led to a strong decrease in mineral losses to the environment in practice in the years thereafter. Moreover, it led to more insight into the flows of minerals at farm level and to the development of practical tools for farmers. For example, in the Netherlands the model ANCA (Annual Nutrient Cycle Assessment) was developed (Aarts *et al.*, 2015) to provide insight to farmers into the impact of their management on the functioning of nutrient cycles. From 2015 onwards, ANCA will serve as a licence-to-produce for the dairy farms in the Netherlands with a manure surplus (which is about 70% of the number of farms). It will ensure that losses are minimised as much as possible.

## Grazing

Another concern is the decrease in grazing. Table 2 shows this for Flanders. The same trend can be seen in the Netherlands where the percentage of dairy cattle with grazing decreased from 90% in 2001 to 70% in 2013. Grazing of dairy cows has several advantages, like more possibilities to express natural behaviour of dairy cows and the contribution to the image of the dairy sector, but also disadvantages, like more nitrate leaching and a less balanced diet (Van den Pol-van Dasselaar *et al.*, 2008; Hennessy *et al.*, 2015). It even affects the quality of the milk, since grazing increases the levels of unsaturated fatty acids in milk and meat (e.g. Elgersma *et al.*, 2006). During the last decade the decrease in grazing has become a societal issue, especially in the Netherlands (e.g. Elgersma, 2012). Public debates emphasize the high perceived-value of grazing for animal welfare. The grazing cow is even seen as an icon of the Netherlands. Therefore, in 2012 a voluntary agreement, the 'Treaty Grazing', was signed by many partners in the Netherlands with the aim of stabilising the number of dairy farms that practise grazing. By now, around 60 parties have signed the agreement indicating the importance of grazing in the Netherlands. Among the parties signed are representatives of dairy farmers' associations, dairy industry, feed industry, milk robot industry, banks, accountants, semen industry, veterinarians, cheese sellers, retail, NGOs, nature conservation, government, education and science. Related to this agreement, Dutch dairy companies currently provide the farmers that deliver milk a so-called grazing premium when they allow their cows to graze. The largest dairy company of the Netherlands raised this grazing premium on 1 January 2015 from 0.5 eurocent kg<sup>-1</sup>

milk produced to 1 eurocent kg<sup>-1</sup> milk produced. 'Pasture milk' is processed in separate milk streams and the majority of the Dutch supermarkets only sell such milk. There has been a revival of grazing in advice, education and science. The activities are expected to lead to a stabilisation of the number of dairy cows grazing. Recently, the Dutch Ministry of Economic Affairs has expressed their ambition to increase the percentage of grazing dairy cows to 80%. The challenge for Dutch farmers will be to combine these ambitions with animal welfare, environmental quality, ongoing upscaling and increasing use of automatic milking systems (AMS). Currently, 17.5% of all dairy farms in the Netherlands milk with an AMS and this percentage is increasing. In Flanders, the percentage stabilises at around 9%. Automatic milking often coincides with less fresh grass in the ration. Further upscaling is also a threat for grazing, since in general, large farms practise less grazing. These issues are addressed in research, e.g. in the European project Autograssmilk, which aims to develop and implement improved sustainable farming systems that integrate the grazing of dairy cows with automatic milking ([www.autograssmilk.eu](http://www.autograssmilk.eu); O'Brien *et al.*, 2015).

## Recent developments

As a result of the abolition of the milk quota, further scaling and intensification is expected to occur in Flanders and the Netherlands. The Dutch government recently installed new legislation to avoid an extensive increase of the herd size without an accompanying increase in the land area. If the excretion of P minus the permitted P-fertilisation of a farm exceeds 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (this is the case for approximately 10% of the current Dutch farms) and the herd size increases, then the farm is obliged to buy or rent land to receive at least 50% of the extra P produced. The other 50% can be exported from the farm. If the P surplus of a farm is between 20 and 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (approximately 15% of the Dutch farms), the farm is obliged to buy or rent land to receive 25% of the extra P produced. In all other situations, 100% can be exported from the farm. This legislation is expected to slow down excessive growth of farms in the Netherlands. A further limitation may be that the national phosphate ceiling, as agreed within the EU, will be exceeded, which may prevent further growth of the national dairy sector.

Also in Flanders, farmers who want to intensify or extend are confronted with legal restrictions. Farmers need to have nutrient-emission rights to keep animals on the farm. In 2015, the 5<sup>th</sup> manure action plan (MAP5) started in Flanders, with restrictions and regulations for N and P in the period 2015-2018. MAP5 focuses particularly on a reduction of the P-fertilisation. Finally, there is the programmed tackling of nitrogen to reduce the output and the effect of ammonium on nature in the neighbourhood of the farm. This aspect is integrated in the environmental licence.

However, even though the recent developments in Flanders and the Netherlands may slow down the further scaling and intensification, the baseline for dairy production is still good. The infrastructure is good (harbours, airports, roads), and therefore materials that are needed can easily be accessed. The Dutch agrosector is important for the Dutch economy; it ranks together with France in second place on the list of exporters of agricultural products, behind the United States. The Netherlands is a world-leading exporter of milk and milk products. Furthermore, there is a good knowledge infrastructure in Flanders and the Netherlands (universities, schools, advisory, farmers associations) that enables farmers to quickly assess up-to-date information to optimise their farm management.

## Outlook on the future of dairy systems in Flanders and the Netherlands

Some of the problems encountered within high output dairy farming systems in Flanders and the Netherlands are addressed in this paper and some solutions are presented. There are, of course, many questions remaining. To what extent will societal demands, such as animal welfare, grazing and environmental quality, be met in intensified production systems? Will further optimization of grassland management enhance profitability and reduce environmental pressure of farming systems? An integrative approach for grassland management that is cost effective, environmentally sound and manageable

is essential in the context of the development of large-scale dairy enterprises with highly productive healthy animals. New functions of high output dairy farming systems may arise with corresponding revenue models, e.g. energy production, emission trading, and provision of other ecosystem services like cultural services. A diversity of dairy farming systems may develop. Van den Pol-van Dasselaar *et al.* (2014) showed in a survey with approximately 2000 respondents from different countries of Europe (mainly from Ireland, France, Belgium, the Netherlands, Poland and Italy) that the individual functions of grasslands are highly recognized and appreciated by all relevant stakeholder groups in Europe. All stakeholders considered that the large European grassland area is a valuable resource which is essential for the economy, environment and people. This could be exploited.

Further development of the dairy sector will require continuous development of people (education, training), tools (e.g. decision support systems) and techniques (innovations like sensors at cow and field level or techniques for manure refining). These developments are taking place in practice. Grasslands can remain as an essential part of dairy farming systems, producing feed for the dairy cattle. Grass production and utilisation should be stimulated by good grassland management, managing constraining factors like water shortage and using highly productive grass varieties and legumes. Soil (fertility) data, together with fertilization registration, grass growth, weather data etc., collected at different resolutions, scales, time, and together with historical data could all be integrated in decision support systems. Multiple layers of information need to be analysed and assessed. This data assessment, evidently, needs to increase grassland yield, improve herbage quality and ensure a prudent use of nutrients. It is also essential to increase the net yields of grazed pastures by reducing the grazing losses (trampling, urine and faeces) and by developing novel grazing systems for future dairy farms (large-scale, high productive, highly automated) that are technically and socially feasible and are economically viable and environmentally sound. The potential to improve the grass yield is enormous as can be seen by the current variation in grass yield in practice. Optimal use of grassland will lead to profitable farming with minimised environmental impact while addressing demands from society like animal welfare and grazing.

## Conclusion

The number of political, economic and societal demands, both regional and European, that challenges high output dairy farming systems in Flanders and the Netherlands, is increasing. There are many challenges and constraints related to grasslands and forages, e.g. with respect to nutrient losses and grazing. The dairy farming sector in the Netherlands and Flanders shows much variation but also has a lot in common. It is well equipped to take its role in global food security, due to its high output contributing to actual food supply and due to the fact that it demonstrates the combination of high output and production of different ecosystem services. Solutions to problems are tailor-made and available at various levels, e.g. introduction of innovative tools and techniques and improvement of skills and expertise of farmers and farm advisers. Further scaling up and intensification is thought to be possible because of high soil fertility, favourable weather conditions, a good infrastructure and well-educated farmers.

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