“*Why grasslands*?”: Insights from Farm Case Studies in the Netherlands and Flanders

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Abstract

The specific use of grasslands depends on factors such as location, land management practices and local policies. In the Netherlands and Flanders, grasslands are mainly used for livestock farming, especially dairy farming. The population density in these regions has led to increased competition for land. In both the Netherlands and Flanders there has been a trend of scaling up and intensification in dairy farming, to meet the growing and changing demand for food and animal protein production. This trend has been driven by high costs for land and labour and low costs for fertilizer and concentrates. Due to increasing competition for land and intensification, grasslands and grazing practices are under pressure in the Netherlands and Flanders. This may lead to additional losses, as grasslands not only provide high quality roughage, but also a variety of ecosystem services. The positive impact of grasslands through its services are gaining attention among Dutch and Flemish dairy farmers. Here we present the results of a survey conducted on ten commercial dairy farms in the Netherlands and Flanders that use grassland and perform grazing. The farms were not selected to be representative, but they do provide a portrait of the variable landscape in the region. Based on the multifaceted benefits of grasslands that resulted from the survey we emphasize the importance of preserving grasslands and grazing in the Netherlands and Flanders, fitting in with the theme of the conference “*Why grasslands*?”

Keywords: ecosystem services, Farm Case Studies, Flanders, grassland use, the Netherlands

Introduction

The aim of this paper is to provide insight into key developments around grasslands in the Netherlands and Flanders, i.e. the Dutch-speaking part of Belgium. The Netherlands and Flanders are the scope of the Dutch-Flemish Society for Grassland and Fodder Crops (NVWV, www.nvwv.nl/en) that organised the 30th General Meeting of the European Grassland Federation in 2024. Flanders and the Netherlands have much in common, not only from a linguistic point of view, but also from a historical, geographical/ geological/ pedological, demographic and economic point of view.

This paper consists of four parts. First, the literature is consulted to provide an overview of the developments in the past decades. Van den Pol-van Dasselaar *et al.* (2015) and Reheul *et al.* (2017) provided an overview of developments in the Dutch and Flemish grass-based sectors up to the respective years of their publications. Policy changes in the dairy sector, such as the abolition of milk quotas, the introduction of phosphate quotas and the phasing-out of derogation, have further impacted the industry. The derogation allowed dairy farms in the Netherlands under certain circumstances to exceed the standard EU application limits of nitrogen (N) from organic manure. Klootwijk *et al.* (2016) and Alderkamp *et al.* (2024) have analysed the impact of these changes on the dairy sector. Second, the current status of grassland-based farms in the Netherlands and Flanders is outlined. Third, farm profiles of ten commercial dairy farms in the Netherlands and Flanders are used to illustrate grassland use in the local context. Finally, the overview of developments in the sector and the examples of dairy farms are used to demonstrate the ecosystem services that grasslands provide in the Netherlands and Flanders, which fits well with the conference theme "*Why grasslands*?"

Recent developments in grassland use in the Netherlands and Flanders

Van den Pol-van Dasselaar *et al*. (2015) showed a trend towards scaling up and intensification on Dutch and Flemish dairy farms to meet the growing and changing demand for food and animal protein production. This trend was driven by high costs for land and labour and low costs for fertilizer and concentrates and led to huge changes in the dairy sector. In the period 1965–2015, the average number of dairy cows per farm in the Netherlands increased tenfold to around 85, the average milk production per cow doubled to just over 8000 kg milk cow^{-1}, and the average milk production per ha of total farmland tripled to around 15 000 kg ha^{-1}. At the same time, the number of dairy farms declined tenfold to around 18 000 (Van Dijk *et al*., 2015). The increase in dairy cows per farm, milk production per cow, and milk production per hectare highlights the intensification in dairy farming. High-output dairy farms in the Netherlands and Flanders are characterized by high nitrogen (N) and phosphorus (P) flows, which require efficient nutrient management. Oenema and Oenema (2022) showed the nitrogen and phosphorus use efficiencies (NUE and PUE) in Dutch grassland-based dairy farms after correction for externalization of purchased animal feed and exported animal manure. The corrected NUE varied from 31–33% and the PUE from 44–78% when related to feed efficiency. Van den Pol-van Dasselaar *et al*. (2015) emphasized that challenges and constraints related to nutrient management, grazing, and societal demands need to be addressed for sustainable and profitable farming. They stressed the need for sustainable intensification of dairy farming, taking into account environmental, economic and societal aspects, and highlighted the importance of grassland in addressing these challenges.

The abolition of the European Union's milk quota system in 2015 has provided a further impetus for the expansion and intensification of the dairy sector. Milk quotas were introduced in 1984 to reduce the oversupply of European milk that affected milk prices at global level. In 2015 they were abolished due to substantial growth in global demand for milk. The effects of the abolition of the European milk quota system in 2015 were examined by Klootwijk *et al*. (2016). The abolition allowed farmers to increase milk production, which also raised concerns about environmental impacts, such as nitrogen and phosphate pollution, and greenhouse gas emissions. The Netherlands, with its high livestock density, faced the challenge of complying with the European Nitrates Directive, which led to the introduction of the so-called "Dairy Act" in 2015 (Klootwijk *et al*., 2016). This act aimed to support the growth of the dairy sector while limiting phosphate production. Due to the introduction of this Act, further significant growth in farm intensity was deemed to be unlikely (Klootwijk *et al*., 2016). The study of Klootwijk *et al*. (2016) further showed that several factors, including manure policy, costs, and phosphate quotas, were expected to limit the growth of Dutch dairy farms after quota abolition to a potential increase in farm intensity (in litres milk ha^{-1}) of 4–20%.

Currently (2024), stricter nitrogen (N) policies are implemented including the phasing out of the derogation. The derogation allowed dairy farms in The Netherlands to exceed the application standard of 170 kg N ha^{-1} from organic manure. Alderkamp *et al*. (2024) investigated the potential impact of these stricter N policies on a typical Dutch dairy farm using a linear programming model with economic optimization. They considered the abolition of the derogation, which is part of the 7th Nitrates Action programme, in their model. The results indicated changes in farm dynamics, such as an increase in the share of maize land and a decrease in the number of dairy cows per farm. The results of Alderkamp *et al*. (2024) show that stricter N policies lead to a lower farm income, mainly due to lower revenues from milk yield and higher costs for manure disposal. These economic factors, alongside environmental and legal considerations, play a crucial role in decision-making on the farm.

The study by Alderkamp *et al*. (2024) also evaluated the effects of using grass-clover swards on dairy farms as a strategy to mitigate negative economic consequences of stricter N policies. The use of grass-clover swards showed the potential to partly compensate for the negative economic impacts (50–78%) of derogation phasing out, while at the same time reduce greenhouse gas emissions (2–6%). However, there were trade-offs between economic and environmental objectives, underlining the complexity of decision-making for dairy farmers. The study acknowledged uncertainties and constraints, including the influence of variations in feed availability and quality, market price fluctuations, and challenges associated with implementing grass-clover swards, such as maintaining the desired legume share in the sward.

Prospects for a sustainable intensification of grass and forage crops are given by Reheul *et al*. (2017). Given the scarcity and elevated price of land and labour in the region of Flanders and the Netherlands the concept "more knowledge per ha" offers the best opportunities to improve the eco-efficiency of grass and forage crops. Levers proposed for sustainable intensification are, firstly, cropping system based on ley arable rotations. Especially in regions where the share of forage maize in the arable land is important, ley-arable rotations offer opportunities to reduce the use of mineral N and herbicides (Van Eekeren *et al*., 2023). Secondly, taking profit of genetic progress in maize and grass and clover varieties can improve feed autonomy and reduce environmental impact. In forage maize breeding, starch content and cell-wall digestibility steadily increased over the last decades. Moreover, very early maturing varieties were bred, which allowed catch crops (Italian ryegrass or rye) to be established after harvesting maize, thus reducing N leaching after maize harvest. In grass breeding, varieties are bred with an improved ability for growing with clover, which could result in more productive and more stable grass-clover leys (Cougnon *et al*., 2024). In drought resistant species like tall fescue (*Festuca arundinacea*) and cocksfoot (*Dactylis glomerata*), breeding resulted in varieties with an improved feeding value. Thirdly, an efficient and modern mechanisation allowing a timely organisation of forage harvest safeguards the quality of the harvested forage. It can also limit the environmental impact of activities like, e.g., slurry application.

Current status of grass-based farms in the Netherlands and Flanders

Grass-based farms in the Netherlands

In 2023, there were 3.8 million cattle in the Netherlands (CBS, 2024). The main categories of cattle were dairy cows (1.6 million), youngstock on dairy farms (1.0 million) and veal calves (1.0 million). The number of dairy cows peaked shortly after the abolition of the milk quota in 2015, after which the number of dairy cows decreased to its current level of 1.6 million. In addition to cattle, there are 0.8 million sheep and 0.6 million goats and 0.1 million horses and ponies in the Netherlands. In 2023, only 14 000 of the original 18 000 dairy farms in 2015 were left, i.e. a decrease of 20% in less than 10 years. The average number of dairy cows per farm increased to 110 cows plus accompanying youngstock and the average milk yield to more than 9000 kg cow^{-1}. Currently, 34% of all dairy farms milk with a robotic milking system (KOM, 2024).

Around 55% of the Utilised Agricultural Area (UAA) in the Netherlands is devoted to grasslands and forage crops. This area is slowly decreasing due, e.g., to urbanisation. In 2023, the area of permanent grasslands was approximately 670 000 ha, the area of temporary grasslands was 200 000 ha and the area of natural grasslands was 90 000 ha. The area of forage crops amounted to 195 000 ha. The majority of this forage crop area, i.e., 180 000 ha, was used for silage maize (CBS, 2024). The total area of grasslands has decreased in the last decade by around 5% and the total area of forage crops by 15%. The average area of a Dutch dairy farm is around 64 hectares of land for grassland and fodder crops (Agrimatie, 2024).

The temperate maritime climatic conditions favour abundant grass growth. The annual average DM yield of perennial ryegrass in Value for Cultivation and Use (VCU) trials in the Netherlands was 12.5 t ha^{-1}

in the period 1975–2015. Between 1990 and 2016, the average annual grass DM yield on dairy farms was 11.1 t ha^{-1} (Schils *et al.*, 2020). After 2016 the average grass production on dairy farms decreased towards 10 tonnes DM ha^{-1}, mainly due to variation in weather conditions. In the dry year 2018, for example, production was just over 8 tonnes, while in the good grass year 2021, production was again 11 tonnes DM ha^{-1} (Agrimatie, 2024).

The majority of dairy farms (83%) practise some form of grazing of dairy cows during the season (ZuivelNL, 2023). The grazing season usually lasts from April to October, and the average number of grazing days per year is 160 days for dairy cows that graze. It is common practice to provide supplemental feeding to the animals in the barn during the grazing season. The figures on grazing for young stock are somewhat lower: 39% of dairy farms graze young stock of less than one year old, and 62% graze young stock older than one year. When focusing on the animals that graze, there are also large differences between dairy cows and young stock. The annual number of grazing hours is 1300–1350 hours per season for dairy cows, 2300–2400 hours per season for young stock younger than one year, and 3200–3400 hours per season for young stock older than one year (CBS, 2024). As the increase in cow numbers per farm during the last decades was not followed by an equal increase in the amount of grassland per farm that is accessible for grazing, the amount of grazing is negatively correlated with the size of the farm. The percentage of grazing dairy farms was at its lowest in 2014 with 78%. Thereafter it increased again till 2020 and has been rather stable since then. The increase since 2014 was mainly due to larger farms (>100 dairy cows) that started grazing again. The increase in grazing was supported by grazing premiums, development of new simple grazing systems (like the New Dutch Grazing), and support from research, education, advice and society.

Grass-based farms in Flanders

In 2023, there were 1.25 million cattle in Flanders, including 350 000 dairy cows and 147 000 beef cows, mainly from the Belgian blue breed (Statbel, 2024). The total cattle population decreased by around 70,000 animals during the past decade, as the proportion of young stock also decreased significantly. The number of cattle farms is steadily decreasing, while the average farm size is increasing proportionally. On average, farms that specialised in cattle had 157 cattle-units on their farm in 2022 (Statbel, 2024). Despite the strong decrease in the number of beef cows (–30 % in the last 10 years), beef cows remain relatively important in Flanders compared to the Netherlands: 5831 farms or 25% of all active farms in Flanders had beef cattle in 2022. As a result of the abolition of the milk quota in 2015, the dairy sector became specialised. The number of dairy cows increased by around 60 000, whereas the number of farms with dairy cattle decreased with 18% (since 2012). There were 4593 farms with an average of 77 dairy cows in Flanders in 2022; 2609 of these were specialised dairy farms having on average 106 dairy cows.

To supply these cattle with feed, around 350 000 ha or over 50% of the available agricultural land is used to grow fodder crops. In 2023, this included over 160 000 ha of permanent grasslands, 52 000 ha of temporary grasslands and 117 000 ha of maize for silage. This distribution has remained relatively stable for several years. The average size of Flemish farms was 28 ha, whereas farms specialised in cattle have an average size of 58 ha.

Grasslands under pressure in the Netherlands and Flanders

The area of grasslands and arable land is decreasing year by year as more and more agricultural land disappears from the sector (Verhoeve, 2015). In Flanders, 180 000 ha of the 780 000 ha designated as agricultural land are currently used for other purposes such as pastures for hobby animals, gardens, recreational areas, housing, gardens, and nature. Horses in particular occupy an increasing share of the grasslands. The number of horses in Flanders is approaching 200 000 animals, requiring approximately 150 000 hectares of grassland (De Morgen, 2024). The shrinking agricultural area and the competition between sectors is driving up the price of agricultural land, as there are many interested buyers. As a result, Flanders ranks third in the European ranking of prices per hectare of agricultural land with an average price of approximately €65 000 ha^{-1} (after Malta and the Netherlands). In the Netherlands, the average price in 2022 was approximately € 85 000 ha^{-1}, with very large differences between regions, ranging from €65 000 to €150 000 (Eurostat, 2024).

Increasing management intensity makes grazing a greater challenge on many farms. In addition, more extreme weather conditions in the context of global climate change pose an additional challenge for the production of grass of sufficient quality. Nevertheless, there are several trends that encourage dairy farmers to engage in grazing. Several dairies pay a premium of about 1–2 euro per 100 kg milk to dairy farms who graze their cows. This has led many dairy farmers to rediscover grazing and there is a great demand for knowledge about grazing on a modern dairy farm. Next to a grazing premium there are also dairies who pay for a plus on animal welfare, the reduction of GHG emission per kg of milk and biodiversity measures. For the latter a Biodiversity Monitor with Key Performance Indicators (KPIs) has been developed for dairy farming which is implemented by the dairy industry in an independent standard (Erisman *et al*., 2016; Van Eekeren *et al*., 2015; Van Laarhoven *et al*., 2018).

Grassland use on ten commercial grass-based dairy farms in the Netherlands and Flanders, a case study

The ten dairy farms

To give a better insight into the grassland use on commercial grass-based dairy farms, we interviewed ten dairy farmers in the Netherlands and Flanders which have a special relationship with grass. We asked several questions like "How is the grassland used?" and "Why grasslands?" Figure 1 shows the location of the selected farms in the Netherlands and Flanders.

Figure 1. Locations of the selected farms in the Netherlands and Flanders.

The farms were not selected to be representative of dairy farms in the Netherlands and Flanders, but they do provide a portrait of this variable landscape in the region:

- F1 is a farm in the north of the Netherlands on a clay soil. The farm has implemented special grassland management to support meadow birds.
- F2 is also located in the north of the Netherlands on a clay soil. This farm only feeds grass as roughage in the ration.
- F3 is located in the west of the Netherlands on a peat soil near Amsterdam. The farm has implemented special grassland management to support meadow birds. In addition, the farm has many visits of guests from the region who are educated on the farm.
- F4 is located in the south of the Netherlands on a sandy soil. This farm is part of the so-called 'Cows and Opportunities' network - a group of farmers who are very committed to reducing emissions to the environment.
- F5 is a farm in the east of the Netherlands on sandy soil that conducts practical research into clover, species-rich grasslands and water management. The animals on this farm graze but are also fed fresh grass in the barn.
- F6 is an organic farm in the west of the Netherlands on peat soils which, like F2, only includes grass as roughage in the ration.
- F7 is an organic farm located in the south of the Netherlands on a sandy soil. It uses the "short grass (i.e. kurzrasen)" grazing system to ensure high-quality grass intake and to maintain white clover in the grass-clover sward. Kurzrasen is a continuous grazing system, in which the sward height is always kept between 3 and 5 cm.
- F8 is a dairy farm in Flanders with good arable land and permanent grasslands which are frequently flooded in winter, making their management very challenging.
- F9 is an organic dairy farm in Flanders on a sand/clay soil. It uses a dual-purpose breed and was nominated for the most beautiful pasture in Flanders in 2023.
- F10 is located in the centre of Flanders on a sandy soil. This farm, just like F1, F3 and F6, has no arable land.

HOW are the grasslands used?

The ten farms dairy farms are characterised in Table 1. The available area of the farms is between 35 and 100 ha and the number of dairy cows per farm varies accordingly. Most of the farms also have an area available for the cultivation of arable crops. The arable crops are mostly fodder crops e.g. silage maize, other cereals for whole crop silage and/or fodder beets (farms F4, F5, F7, F8 and F9; not shown), but sometimes the crops are grown for external use or for sale (e.g. grains on farms F2 and F8, sugar beet on F9; not shown). Grassland management varies from farm to farm. Table 1 shows the share of permanent grasslands, extensively managed grasslands and the use of temporary grasslands with grass-clover mixtures, multi-species and Italian ryegrass (*Lolium multiflorum*).

WHAT do the animals eat – is fresh grass included in the ration?

Table 2 shows the ration, the average crude protein content of the ration, and details on the grazing system used. All farms practise grazing. F3, F6 and F9 apply continuous grazing. F8 practises siesta grazing, but the grazed grass is only a limited is not a considerable part of the ration. F8 changed grazing management when they started to use a commercially available 3-NOP (3-nitrooxypropanol) product to reduce enteric methane emission by the cows. Also, F4 mentioned only 5 hours of grazing time per day. Although the cows have constant access to pasture in summer, this is the expected time the cows actually spend on pasture due to the milking system (automatic milking system; AMS). Farm F6 also uses an AMS, but its estimate of actual grazing time is higher.

Table 1. Characteristics of the ten selected farms: number of dairy cows, milk production per cow per year, farm intensity in L per hectare, and land use in hectares: total, arable, grassland, permanent, temporary grass-clover or species-rich, *Lolium multiflorum* as catch crop and extensively managed.

	No. dairy cows	Milk (cow^{-1} year^{-1})	Intensity (l ha^{-1})	Total (ha)	Arable (ha)	Grassland (ha)	Permanent grassland (ha)	Temporary: Grass-clover or species-rich grassland (ha)	*Lolium multiflorum* as catch crop (ha)	Extensively managed grassland (ha)
F1	199	8 000	15.8	101		101	101			Much, but not officially registered
F2	125	8 000	14.1	71	9	62	51	11.5		
F3	134	9 340	14.5	81		81	70			13
F4	130	11 000	26.0	55	10	45	18	25		
F5	188	9 580	21.7	83	18	65	44	21		1.5
F6	52	8 360	10.4	42		42	42			
F7	93	6 450	6.0	100	16	84	56	26.5		27
F8	120	12 070	24.5	59	31	28	24		10	
F9	75	4 000	3.0	100	27	73	60	15	-	35–40
F10	90	9 800	25.2	35		35	11	21.5		2.5

Table 2. Ration and grazing characteristics: % fresh grass, % grass silage, % maize silage, % concentrates+by-products, protein in the ration (all expressed in DM and as year-round average), grazing system used, grazing hours per day and grazing days per year.

	Fresh grass (%)	Grass silage (%)	Maize (%)	Concentrates/ by-products (%)	Protein in ration (g (kg DM)$^{-1}$)	Grazing system	h day^{-1}	days year^{-1}
F1	20	30		50	131	Rotational grazing, "mosaic management"	9	190
F2	25	50		25	158	Strip grazing	12	245
F3	20	37	9	34	158	Rotational grazing	15[1]	210
F4	25	20	35	20	154	Compartmented continuous grazing	5	180
F5	16	26	18	40	157	Strip grazing and feeding fresh grass in the barn	7	224
F6	40	40		20	241[2]	Rotational grazing	18	210
F7	35	40	10	15	145	Short grazing i.e. "Kurzrasen"	14	241
F8	3	23	34	40	164	Siesta grazing	3	180
F9	50	50		n.a.	165	Rotational grazing (twice per day)	20	220
F10	15	35		50	187	Rotational grazing (daily)	8	150

[1]May-Sept: 20 h^{-1} day^{-1}; until May and from Sept–Nov: appr 10 h day^{-1}.

[2]Recent silage analyses indicated that protein in ration was strongly reduced (100-point reduction).

WHAT are the trade-offs to the environment?

To estimate trade-offs to the environment, N-surplus per ha, and CO_2 emissions per kg fat and protein-corrected milk were used. In the Netherlands, these characteristics are calculated annually as part of the 'annual nutrient cycle assessment' (ANCA) (Table 3). The losses to the environment vary greatly and depend on the type of farm (organic versus conventional), intensity of the farm, but also on the type of soil. Especially the high N-mineralisation from the peat soil (F3) influences the N-surplus ha^{-1}. Most farms apply some practices to reduce emissions to the environment. The addition of water during slurry application is very common, which leads to a reduction in ammonia emissions depending on the application method.

Furthermore, most farms reduce the protein content of the ration to reduce nitrogen excretion, try to clean the barn floor regularly and use grazing as a method to reduce NH_3 emissions. A commercially available 3-NOP product is used on F8 and F10 to reduce CH_4 emissions.

WHICH ecosystems services are provided? - biodiversity characteristics and other services

The interviewed farmers declared in the interviews that they do not only produce milk but deliver also other (ecosystem) services (Table 4). Grass-clover and species-rich grasslands are often mentioned and used for several reasons. The first reason is the nitrogen fixation that leads to increased protein content of the forage and decreased use of artificial fertilizers (F2, F4, F5, F6, F9, F10). Other reasons are drought tolerance of the species (F1, F5, F9, F10), biodiversity (F5, F9) and cow health (F5, F9).

WHICH advantages and limitations of grasslands do the farmers in our survey experience?

The farmers in our survey see a number of advantages of grassland. The main advantage is that grassland provides a complete forage that is well suited to cows (F1, F9) and can be grown on soils where other crops are (barely) possible (F1, F3, F8). Grassland also ensures fodder production on dry sandy soils under the current climatic challenges (F10). In addition, fodder and protein production is sufficient for the cows – grazing provides direct utilization of energy and protein - and it makes it possible to harvest protein for the cows on their own farm (F2, F3, F5, F6, F7, F10). One farmer also stated that the N mineralization after ploughing a grassland is a great advantage in the crop rotation because it reduces the nitrogen requirement for the following maize crop (F7). Grasslands also ensure a healthy soil life and high biodiversity in the agricultural landscape and blend well into the landscape. They can help to sequester carbon and reduce emissions (F5, F7, F9, F10). Farmers also like to see cows grazing (F4, F5). Finally, the ability to choose between grazing and mowing is appreciated because it offers ease, safety and freedom (F9).

Table 3. Sustainability characteristics and emissions.

	N-surplus (kg ha^{-1})	CO_2 (kg FPCM)$^{-1}$	Practices to reduce emissions (NH_3/CH_4)
F1	114	1054	Low fertilizations; water to in slurry, low CP in ration, grazing, regular floor shovelling
F2	136	1158	Lower slurry gifts, water to in slurry, low CP in ration, regular floor shovelling
F3	282[1]	1379[2]	Reduced emission stable; low CP in ration, water to in slurry
F4	110	867	Reduced emission floor, water to in slurry
F5	75	981	Low mineral fertilization, longer grazing period, increasing fresh grass, low CP in ration
F6	27	1115	Low CP in ration, grazing, regular floor shovelling
F7	34	1210	Grazing, low stocking rate
F8	n.a.	n.a.	Use of commercially available 3NOP product to reduce CH_4 emissions
F9	n.a.	n.a.	Continuous grazing (to the max)
F10	n.a.	n.a.	Calculation of rations, reduced emission stable, low emission technique (slurry application), use of commercially available 3NOP product to reduce CH_4 emissions

[1] Including mineralization of peat soil: corrected N-surplus: 83. [2] Corrected CO_2 emission: 1028.

Table 4. Ecosystem services and sustainability characteristics on the different farms, as and only if specifically mentioned by the farmers.

		Farms
Biodiversity	Field borders	F4
	Botanical management around ditches	F1, F3, F6
	Bird management and/or extended mowing	F1, F3, F6, F10
	Endangered species conservation program	F8, F9
	Species-rich grasslands	F1, F4, F5, F6, F9
	Management / use grassland on nature areas	F3, F4, F7, F10
	Hedges	F2, F5, F8
	Trees	F8
Mineral efficiency	Legumes	F1, F2, F4, F5, F9, F10
	Adapted fertilization	F2, F4, F5, F6, F9, F10
	Extended grazing	F1, F5
	Reduced imports	F7, F9
C sequestration	Permanent grassland (>10 years)	F1, F2, F5
Pesticide reduction		F5, F6, F7, F9
Energy transition	Solar panels	F1, F2, F3, F5, F6
Cooperation with regional cooperatives		F1, F4, F5, F7, F8, F9, F10
Farmer – citizen – initiatives	Local sales such as milk, ice cream, meat	F1, F3, F9
	Tourism / catering / event location	F3, F8
	Education	F1, F3, F5, F6, F7, F8
	Research	F5

Farmers also pointed out disadvantages, e.g. the feed value is not always suitable for highly productive dairy cows (F1) and the productivity of grasslands is often more variable than that of maize (F4). It is not always possible to graze during longer periods of rain (F2). Drought can also be a problem (evaporation, high water consumption (F4, F5, F7)). In some situations, mineralization is too high, resulting in a high protein content in the grass and making it difficult to offer a balanced ration – this could become even more difficult in the future as inputs (also due to the loss of the derogation) decrease and extensive management increases (F3, F4). The quality of the grass can be unpredictable (also due to weather conditions) and is therefore not always easy to manage (F3, F8, F10). Fertilization and harvesting are time-consuming (~money) (F5, F9) and the renewal of permanent grasslands with poor botanical composition is complicated (F8).

Recommendations from farmer interviews: insights for further research

Farmers were asked to indicate which topics were important to them and should be addressed in future research. A very important aspect was how to keep (permanent) grassland productive and palatable with less fertilization (F2, F3, F4, F6, F10). Nitrogen regulations are becoming stricter, leading to a reduction in the amount of animal manure to be applied. This will also lead to a reduction of minerals other than N: e.g. K, P and S. Further wishes for research into the use of animal manure (F3) and the comparison of nitrogen leaching between animal manure and artificial fertilizers (F5) is linked to this topic.

It was also pointed out that water storage and water management are important (F4, F5) and that grass mixtures are needed that are more persistent and resistant to drought (F10). Furthermore, the rehabilitation of very wet and frequently flooded soils is a problem (F10) and there should be grass species available for less optimal growing conditions (F8). Finally, farmers would like to have more information on tools for optimal grazing (F10), on 100% grass-fed milk production (F9) and on the added value of grassland ecosystem services, especially in terms of the economic value (F1).

WHY grasslands?

In the interviews we asked the opinion of the farmers on the role of grasslands on their farm. Some quotes are given below:

> Farmer F1: *"Grassland is important in our management, for the cows, but also for the whole area and for the meadow birds living on the grasslands."*

> Farmer F2: *"Grassland is the base of our management and delivers energy and protein for our livestock. Furthermore, it is important for soil quality and health. Variation in grass growth, grass quality and grazing is not a problem, but has to be handled as a part of the system."*

> Farmer F3: *"Grassland is an inseparable part of the peat grassland landscape. Furthermore, the management of birds on grassland and biodiversity near ditches are also important on the landscape. The close proximity of the city gives extra potential for tourism."*

> Farmer F7: *"Grassland is the license to produce for dairy farming, because of positive impacts on soil quality and (soil) biodiversity, and the possibility to reduce emissions by grazing (NH_3). Grass is an important protein source and is important for the landscape."*

These quotes underscore the farmers' recognition of the ecosystem services provided by grasslands. The significance of grasslands lies in their ability to offer various ecosystem services, as depicted in Figure 2 (Schils *et al.*, 2022). Figure 2 shows that permanent grasslands are more beneficial for most ecosystem services than croplands and temporary grasslands (indicated by the bullet points in the outer circle). For example, permanent grasslands provide high soil quality (bullet points run-off, soil loss, bulk density), water regulation (hydraulic activity), carbon sequestration and biodiversity (threatened species). Semi-natural grasslands are not included in the figure, but are among others beneficial for water use, N_2O and NH_3 emissions, biodiversity and landscape enhancement. Temporary grasslands perform worse than permanent grasslands for most ecosystem services. Croplands are generally less valued for ecosystem services, except for yield and energy.

Conclusions

The case study was meant to showcase examples of different grassland management use and as a portrait of grass-based dairying in the Netherlands and Flanders. Since the farms have not been selected to be representative of the sector, conclusions should be read having the goal of the case study in mind. The diversity among grassland farms in the Netherlands and Flanders is notable, as illustrated through interviews with ten grass-based dairy farmers. Many of these farmers have adopted various strategies to enhance ecosystem services, for example, incorporating grass-clover mixtures and species-rich grasslands to mitigate nitrogen input and bolster drought resistance. Several farmers have highlighted the growing challenges in sustaining dry matter yield and forage quality in their grasslands, attributed to stricter nitrogen regulations also impacting other vital nutrients like potassium and phosphorus. Moreover, given the prevailing climatic challenges, there is a need to reassess the cultivation and management practices of grasslands and forage crops. Additionally, there is an urgent demand from society for ecosystem services delivery, such as biodiversity conservation, landscape preservation, and water retention. However, their economic valuation remains a subject of exploration.

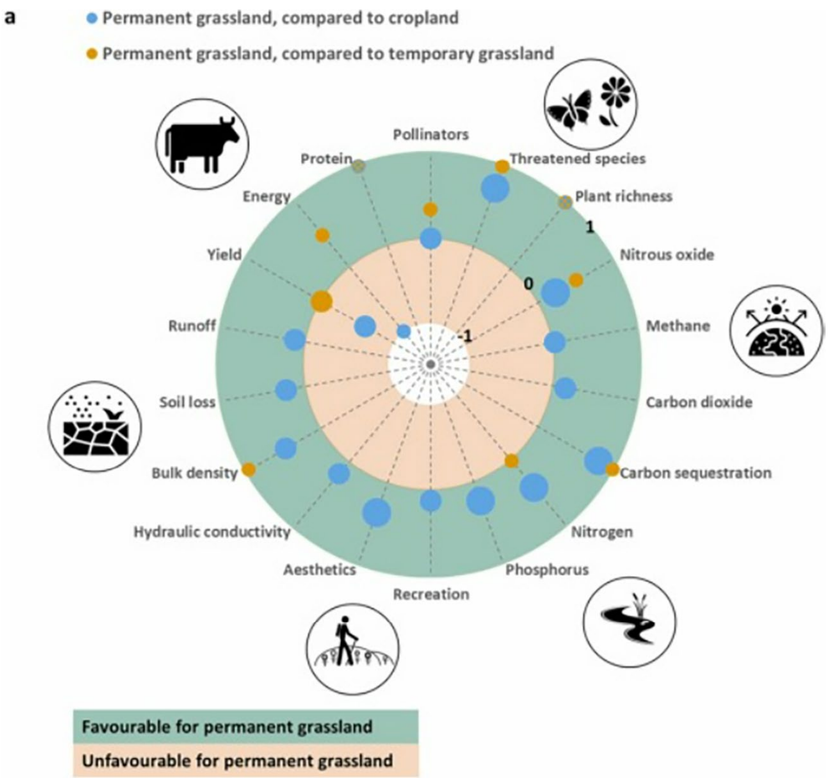

Figure 2. Comparison between land use types for indicators of ecosystem services, permanent grassland compared to cropland and temporary grassland. The boundary between the outer and inner shaded zones represents a mean score of 0. The shaded outer zone represents a favourable score for permanent grassland (moving outwards, the mean score increases from 0 to 1), the shaded inner zone represents an unfavourable score (moving inwards, the mean score decreases from 0 to −1). Dot size indicates number of underlying cases (small: <5 cases, medium: 5–9 cases, large: >9 cases). Source: Schils *et al*. (2022).

In the future, grasslands in the Netherlands and Flanders are expected to face pressure due to increasing competition for land within the agricultural sector (e.g. arable land) and outside the agricultural sector (e.g. urbanisation). Regarding the question of WHY grasslands, farmers cite, next to a high quality roughage for their cows, numerous reasons, including the promotion of biodiversity (birds, insects, soil organisms, plant species), enhancement of soil quality, water retention capabilities, landscape aesthetics (which contribute to tourism), protein yield, feed value, and the overall well-being of cows and farmers. These multifaceted benefits underscore the importance of preserving grasslands in both the Netherlands and Flanders. Considering the increasing competition for land, a payment scheme to valuate these ecosystem services might support preserving these grasslands and their ecosystem services.

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