



Extending the productive lifespan in Swiss dairy herds: Effects on greenhouse gas emissions, land use, and gross margin

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ABSTRACT

This study assessed the effect of extending the productive lifespan of dairy cows on GHG emissions, land use, and economics in representative Swiss systems, which differ by breed, zone, and production system. Life cycle assessment was applied to short, medium, and long productive lifespans derived from 5 yr of herd-book data, using 3 functional units: per dairy production unit (a cow including replacements), per tonne of milk, and per tonne of protein of dairy cows. Longer productive lifespans reduced emissions and land use in all systems, driven by a reduced need for replacement animals. Greenhouse gas emissions per tonne of milk declined consistently, even when milk yields were lower in long-lifespan systems. Across all GHG-related metrics, long productive lifespans outperformed those of shorter duration. Organic and extensive systems performed as efficiently as intensive systems per tonne of milk. Yet, mid productive lifespans produced the highest gross margins under current prices. Healthier cows reaching later lactations can increase milk output and productive lifespan without additional costs, and fewer replacements free up land that could generate income if used for agri-environmental payment schemes or if more animals are kept. Overall, extending productive lifespan reduces environmental burdens, and the profitability of a longer productive lifespan system could be improved when land-use opportunities are realized.

Key words: dairy cow longevity, CO₂ emissions, life cycle assessment, land use, gross margin

INTRODUCTION

Livestock, particularly ruminants, are a key driver of humanity's transgression of planetary boundaries (Bowles et al., 2019), contributing to both climate

change and biodiversity loss (Pörtner et al., 2023). Over the past century, the global livestock population has expanded rapidly, making it a major source of agricultural GHG emissions, largely through methane from enteric fermentation. Although improved management practices have lowered emissions per unit of product, total emissions remain high due to herd expansion (Gingrich et al., 2024). Research on emission reduction has focused mainly on technical measures such as feed additives (Dittmann and Leiber, 2024; Hristov, 2024), feeding more digestible rations (Hristov et al., 2022), or improved manure management (Yan et al., 2024). Such measures reduce emissions per unit of output but do not address another major challenge: livestock occupies most of the world's agricultural land (van Zanten et al., 2016), creating additional pressures on ecosystems and driving biodiversity loss. Ruminants rely on both grassland and cropland for feed, whereas grassland is often unsuitable for food crops and as such a noncompeting source for ruminant nutrition (Leiber et al., 2017), the use of energy-rich feed crops competes directly with human nutrition (van Zanten et al., 2023). Substituting such crops with byproducts could free up to 27.8 million hectares of land (Govoni et al., 2023), which could instead be used to support biodiversity or sustainable crop production for human consumption.

An often-overlooked lever that addresses both GHG emissions and land use is the prolongation of the dairy cow's productive lifespan. Defined as the period between first calving and culling or death (Dallago et al., 2021), the productive lifespan determines the number of lactations and calves produced. Longer lifespans reduce the need for replacement animals, thereby lowering sectoral GHG emissions (Grandl et al., 2019) and releasing land that could serve other functions. However, although prolonging the productive lifespan of cows can be achieved without necessarily increasing health problems or veterinary costs (Bieber et al. 2024), it may come at the cost of more extensive management with lower milk yields, which could undermine the gains from reduced replacement animals. Conversely, at the animal level,

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The list of standard abbreviations for JDS is available at adsa.org/jds-abbreviations-26. Nonstandard abbreviations are available in the Notes.

milk yields of dairy cows continuously increase to reach a peak around the fourth or fifth lactation before stabilizing (Grandl et al., 2019; Rödiger and Home, 2023). Additionally, herdbook evidence shows that cows with a long productive lifespan also tend to start with a lower milk yield but will achieve a higher average yearly lifetime milk yield (Leiber, 2001). One reason for this pattern is that animals with a longer productive lifespan are often kept in more extensive grazing systems, which promote health and longevity but typically have lower milk yields (White et al., 2002). Reducing concentrate use can lower the embedded GHG emissions associated with purchased feeds compared with roughage, especially when these involve land-use change (de Vries et al., 2015). However, roughages and many byproducts have lower digestibility, which can increase enteric methane emissions per cow and per liter of milk (Hristov, 2024). Thus, the management factors that support a longer productive lifespan, such as increased grazing combined with a reduction of concentrate feed, may simultaneously reduce emissions from feed production but raise emissions from digestion, making the overall GHG outcome uncertain. When these dynamics are aggregated across the whole herd and farm system, where replacement rates, feed rations, and productivity interact, the actual effect of prolonging productive lifespan remains largely unknown.

The objective of this study was to identify the conditions under which prolonging dairy cow productive lifespan at the farm level reduces GHG emissions and land use while remaining economically viable for a farm. Virtual representative farms with varying plausible combinations of productive lifespan, protein yield, including milk and feed intake, were modeled and assessed using a combined farm system and life cycle assessment (LCA) framework, enhanced with a gross margin analysis. The implications for farmers and other food system actors are also discussed, providing a comprehensive understanding of this approach's potential benefits and challenges.

This paper is structured as follows. The methods section first describes the construction of virtual representative farms then details the model used to quantify GHG and land use and finally outlines the farm characterization aligned with model requirements. The results section reports GHG emissions, land use, and gross margin outcomes. The discussion places the findings in a wider context.

MATERIALS AND METHODS

Representative Farms for Swiss Dairy Production for Different Agricultural Zones

To capture the heterogeneity of Swiss dairy production, a set of virtual representative farms was constructed to reflect average conditions across different

contexts, rather than existing individual farms. To ensure representativeness, these virtual farms were defined based on a previous study on dairy production in Switzerland (Bieber et al., 2024) combined with national statistical data and expert knowledge to represent typical combinations of production zone, breed, and production system (organic or conventional, abbreviated as **O** or **C** in scenario codes). The zoning followed the Swiss agricultural classification, which distinguishes between the lowland and hill zone (**LH** in scenario codes; “Tal- und Hügelizeone”), the lower mountain zone (**LM** in scenario codes) up to 1,800 m elevation (“Berg 1-2”), and the upper mountain zone (**UM** in scenario codes) above 2,000 m (“Berg 3-4”). As agronomic and climatic conditions become less favorable with increasing altitude, this zoning also reflects a gradient of production intensities across Switzerland.

The dominant dairy systems were identified for each combination of agricultural zone and production system (conventional or organic) using SwissHerdBook data from 2014 to 2019, which provided both breed distributions and average herd sizes. The representativeness of the herdbook data was verified by cross-checking breed distributions with the national animal registration database (Identitas, 2023; Bieber et al., 2024) at the zone level. To distinguish between conventional and organic systems, registration numbers of organic farms provided by Bio Suisse were used. In addition to the dominant systems, experts highlighted niche systems of particular interest for ongoing debates on transforming the food system. These systems are typically dual-purpose, grass-based herds found in mountain regions, such as Simmental. These dual-purpose breeds represent about 7% of the total dairy population in Switzerland (Qualitas, 2024). Although not dominant, they are represented in the herdbook data and were included because they are considered potentially more efficient in future food systems that aim to reduce competition between livestock and humans for edible resources (Pfeifer et al., 2025).

Virtual representative farms were thus defined as modeling units with fixed attributes: agricultural zone, dairy breed, production system, number of dairy cows, and average live weight of adult cows. Breed-specific live weights were derived from slaughter statistics reported by Identitas (2023), assuming a dressing percentage of 46% (Agridea, 2023). These fixed attributes define the representative farms and remain constant throughout the modeling. The resulting representative farms are summarized in Table 1.

Two critical assumptions were made regarding these representative farms. First, all roughage feed (i.e., feed and fodder other than concentrates) was assumed to be produced on the farm. Second, replacement animals were assumed to be reared on the farm. Although these as-

Table 1. Attributes of the representative Swiss dairy farms

Agricultural zone	Name of scenario	Breed	Number of dairy cows	Alive adult weight (kg)	Production system	System type
Lowland and hill (LH)	BV-LH-C	Braunvieh (BV)	29	636	Conventional (C)	Dominant
	HO-LH-C	Holstein (HO)	31	647	Conventional (C)	Dominant
Lower mountain (LM)	BV-LM-C	Braunvieh (BV)	20	636	Conventional (C)	Dominant
	SF-LM-C	Swiss Fleckvieh (SF)	20	644	Conventional (C)	Dominant
	SI-LM-O	Simmental (SI)	16	632	Organic (O)	Niche
Upper mountain (UM)	BV-UM-O	Braunvieh (BV)	17	636	Organic (O)	Dominant
	SI-UM-O	Simmental (SI)	14	632	Organic (O)	Niche

sumptions do not fully reflect the reality of Swiss farms, they allow for the calculation of a context-specific effect per breed and agricultural zone, regardless of whether feed or replacements are sourced externally. This implies that the reported environmental impacts assume that feed production and animal rearing occur within the same agricultural zone and involve the same dairy breed.

For simplicity, all farms were assumed to use the same amount of bedding per animal, the same manure management system (a mix of solid and liquid manure), and to comply with the Swiss grazing requirements of the RAUS subsidy scheme. Under Switzerland's RAUS direct-payment program, dairy cows must have outdoor access on at least 26 d/mo between May 1 and October 31 (pasture) and on at least 13 d/mo between November 1 and April 30 (pasture or an outdoor exercise area; BLW, 2023).

The Life Cycle Assessment Framework

For this study, the FarmLCA tool was used to assess the environmental performance of virtual representative dairy farms from cradle to farm gate on an annual basis (Moakes et al., 2026). FarmLCA combines a farm system model with a LCA framework. Its particularity is that it does not rely solely on background life cycle inventory (LCI) databases to represent the farm as a black box. Instead, it first models the main internal processes of the farm system and then links the remaining external inputs to life cycle inventories.

As shown in Figure 1, the core of the model is the farm system, which consists of 4 connected modules: (1) herd model, (2) livestock production, (3) feed intake, and (4) feed and fodder production. Together, these components represent the main biological and management processes occurring on the farm. Figure 1 also distinguishes between 2 types of arrows. Thick arrows denote calculation links and represent the sequence of modeling steps through which the farm system is simulated, and GHG emissions are calculated. They show how outputs from one module become inputs to the next. Thin arrows denote data transfer only, meaning that a specific variable or data set is passed into another module without constituting a separate calculation step. The first calculation step

is the herd model. It describes the demographic structure of the dairy herd and the flows of animals between categories. Based on this herd structure, the livestock production module quantifies farm outputs such as milk and culled cows. The feed intake module then determines the animals' nutritional requirements and ration composition, whereas the feed and fodder production module calculates the amount of homegrown forage and crops required to meet these feed demands. In parallel, manure produced by the herd is transferred back into the crop and forage production module, where it is considered as a fertilizer input. In this way, the model captures key internal linkages between animal production, feed demand, crop production, and nutrient cycling.

This explicit representation of farm processes is complemented by external LCI data for inputs and processes that are not modeled in detail within the farm system itself. External input LCI databases are used, on the one hand, for inputs related to the livestock side, such as bedding materials, fuel, electricity, and farm infrastructure and, on the other hand, for crop-related external inputs such as synthetic fertilizers, seeds, field operations, and concentrate ingredients. These background processes were linked to ecoinvent v3.8 (Wernet et al., 2016) and Agribalyse v3.1 (Colomb et al., 2015), depending on the input considered. Their GHG impacts were then characterized using the Impact World+ method (Bulle et al., 2019).

1. Herd model

A herd model represents the demographic dynamics of the dairy enterprise (i.e., the flows of animals between age and production categories). The herd model assumes a stable herd viewed on an annual basis. The number of dairy cows is defined as an input, whereas the number of animals in all other categories is calculated based on user input. The number of newborn calves follows from the calving interval. After applying mortality rates, the surviving calves are divided into 2 groups: those required as replacement heifers and those leaving the farm as surplus calves. The productive lifespan of the cows is defined by the replacement rate: A shorter lifespan implies a higher annual replacement rate,

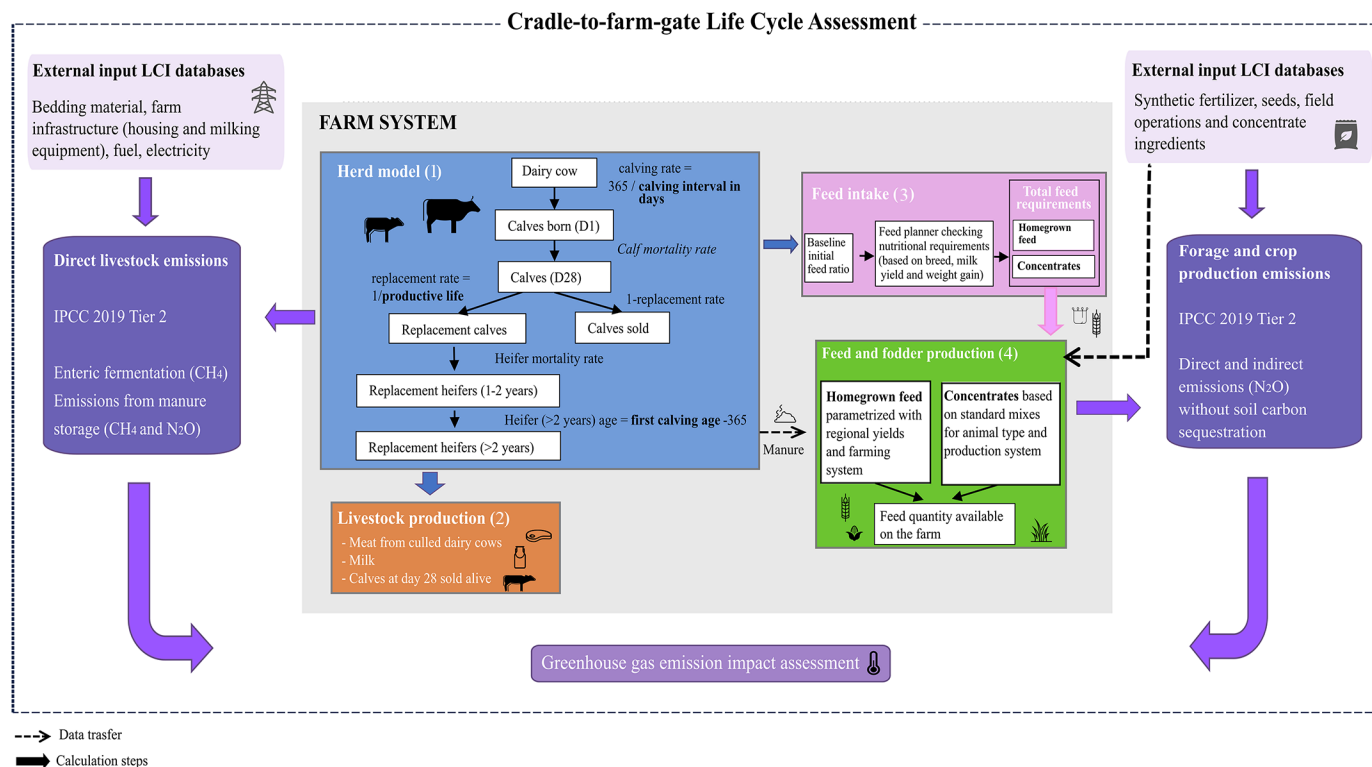


Figure 1. Schematic overview of the FarmLCA framework applied in this study, showing the internal farm system modules, the associated GHG emission calculations, and the integration of external life cycle inventory data.

whereas a longer lifespan lowers it. Replacement heifers enter the herd as first-calving cows, thereby keeping herd size constant. Surplus calves exit the farm at 28 d of age in accordance with the Swiss sectoral agreement. In this study, a “dairy production unit” refers to one dairy cow, together with the annualized share of replacement heifers required to maintain the herd size, and the surplus calves up to 28 d of age, when they leave the system.

2. Livestock production

Milk and meat outputs are derived from the herd model combined with farm-specific productivity data. Annual milk production is calculated as the number of dairy cows multiplied by their farm-specific average milk yield obtained from herd-books. Meat production arises from culled dairy cows. Carcass weight for culled cows is derived from breed-specific live weights and a dressing percentage of 46% (Agridea, 2023). Surplus calves are assumed to leave the farm alive at 28 d of age and therefore do not contribute to meat production within the boundaries of this study.

3. Feed intake

In the FarmLCA, feed intake is calculated using a feed planner. The model begins with a farm-specific initial feed ratio (share of DM from

different feed types) as a starting point for the diet. This initial ratio is not fixed but serves to initialize the calculation. The feed planner then checks whether animals’ nutritional requirements calculated based on Gruber et al. (2006) and on IPCC (2019) are met simultaneously over a full production cycle, and adjusts the ration to ensure an adequate energy, crude protein, and NEL intake. The feed planner applies the Gruber et al. (2006) equation for dairy animals with roughage and grass intake, to estimate DMI for dairy cows based on breed, BW, and milk yield, and for the replacement animals based on breed and weight gain. Once the balanced diet is established, total feed requirements are calculated for each animal category and split into homegrown fodder and purchased concentrates.

4. Feed and fodder production

Once feed intake is established, the feed and fodder production determine the quantity of feed that must be available on the farm. For homegrown feeds, including forage and crops, production is parameterized using representative yields for the region and farming system corresponding to the virtual representative farms. Based on these yields and the required feed quantities, the model derives

the area needed for feed production. Manure produced by the herd is accounted for as an internal fertilizer input within this module, thereby linking livestock production to on-farm feed production.

For homegrown feed production, some technical data are introduced from LCI sources without directly transferring precalculated effects. This applies in particular to field operations such as soil tillage. In these cases, the inventory data are used as process data within the farm model, whereas the corresponding effects are calculated in relation to the farm-specific area and production levels derived by the model.

For purchased concentrate feeds, the model applies standard feed mixes differentiated by animal type and production system, namely organic or conventional. These mixes specify the composition of concentrate feed and are used to determine the quantity and type of purchased feed required by the virtual representative farms.

GHG Emission Calculations

The FarmLCA tool quantifies GHG emissions from the main sources associated within the dairy enterprise. Results are expressed in CO₂-equivalents using GWP100, with methane (CH₄) converted using a factor of 28 (IPCC, 2023).

Direct emissions from livestock are calculated using the IPCC Tier 2 approach and include CH₄ from enteric fermentation as well as methane and nitrous oxide (N₂O) from manure management. For crop and forage production, direct and indirect N₂O emissions from fertilizer application are likewise calculated using IPCC equations. Soil carbon sequestration is not included in the present assessment.

Emissions from external inputs and background processes are represented through the inventory data described in “The Life Cycle Assessment Framework” section and scaled to the quantities used on the virtual representative farms.

Functional Units

In LCA, the functional unit (FU) serves as the basis for comparing systems. It expresses the total environmental impact of the system in relation to a defined output, known as the reference flow. In the context of this study, the FU is calculated as

$$FU = \frac{\text{total GHG emission of the farm}}{\text{reference flow}}.$$

Three reference flows are applied in this study: (1) the dairy production unit; (2) total milk produced, expressed

in tonnes; and (3) total protein produced, expressed in tonnes from both milk and meat.

These functional units were selected to separate the mechanisms through which productive lifespan influences emissions. Four effects were defined. The replacement effect refers to changes in the number of replacement animals required to maintain herd size. The feed effect refers to differences in feed intake at the cow level, both in quantity (DMI to meet gross energy requirements) and in composition (forage-to-concentrate ratio), which happens across systems with different lifespan. The milk effect accounts for the change in annualized average milk production resulting from a longer production lifespan. The meat effect reflects differences in beef protein supplied through culling of cows leaving the herd, which always decreases as lifespan increases, as fewer animals are culled.

Each FU captures a cumulative set of these effects. Emissions per dairy production unit capture the replacement and feed effects. Emissions per liter of milk capture replacement, feed, and milk effects. Emissions per kilogram of protein capture replacement, feed, milk, and meat effects.

Although this design is tailored to reveal how productive lifespan changes emissions dynamics, it is not intended to produce product-level carbon footprints. In the milk-based FU, all farm emissions were attributed to milk without allocating a share to meat. As a result, FU related to milk calculated in this paper cannot be compared directly with other studies. Meat was accounted for explicitly in the protein FU. This approach departs from allocation-based conventions, such as Livestock Environmental Assessment and Performance Partnership (LEAP) (FAO, 2016), and in order enable the study of the mechanisms through which productive lifespan influences emissions than conventional footprinting milk or beef.

Profitability Calculation

The FarmLCA tool was enhanced with a profitability calculation module based on a gross margin approach per dairy production unit. Gross margin is defined as the difference between revenue and variable costs, providing a measure of the financial performance of agricultural systems. In this module, the gross margin is calculated by assessing the revenue and costs from each system, excluding the farmer's own labor, the cost of producing homegrown feed, and subsidies. Input and output prices, including the potential payments for agri-environmental schemes, along with assumptions about dressing percentages, were sourced from the Agridea database (Agridea, 2023) for 2022 (see Appendix Tables A1 and A2).

Table 2. Production parameters for an average herd with short, average and long productive lifespan

Scenario	First calving age (d)	Birth rate	Productive life (in lactation)			Milk yield (kg/cow per year)		
			Short	Medium	Long	Short	Medium	Long
BV-LH-C	30	0.87	2.7	3.5	5	6,932	7,196	7,009
HO-LH-C	28	0.88	2.3	3.1	4.4	7,343	7,808	7,875
BV-LM-C	32	0.88	2.6	3.4	4.7	6,299	6,552	6,294
SF-LM-C	29	0.92	2.4	3.7	5.6	5,878	6,366	6,790
SI-LM-O	32	0.96	1.9	3.5	5.3	4,006	4,937	4,950
BV-UM-O	34	0.90	2.8	3.7	5	5,980	5,881	5,556
SI-UM-O	32	0.94	2.7	3.9	5.7	4,429	4,882	4,786

Data Origin

Herd Parameter and Milk Productivity for Different Productive Lifespan. The Swissherdbook data from the period 2014 to 2019 at the lactation level was aggregated to the farm level. This allowed each virtual representative farm to derive an average age at first calving and an average birth rate (calculated as 1 divided by the average calving interval). The average productive lifespan of the herd was calculated from the first lactation to the last available lactation, regardless of whether the cow had left the dairy herd or was still in it. All herds in the sample were ranked by productive lifespan within each agricultural zone, breed, and production system and split into quartiles (**Q1–Q4**). Categories were defined as follows: low productive lifespan = Q1 (lowest 25%); medium lifespan = the mean of Q2 and Q3 (middle 50%); long lifespan = Q4 (highest 25%). Based on this classification, milk yield per agricultural zone, breed, production system and productive lifespan length could be derived. The data allowing for the computation of the herd parameters for each virtual representative farm are shown in Table 2.

At the individual animal level, dairy milk yield should increase as the productive lifespan for all farms is lower than 4 lactations (Grandl et al., 2019), here referred to as physiological effect. At the herd level, however, longer productive lifespans often co-vary with a more extensive management adopted to support health and longevity (De Lauwere et al., 2026). Evidence from the same herdbook at the animal level (Bieber et al., 2026) shows that cows with longer productive lifespans tend to start with lower first-lactation yields, consistent with more extensive systems keeping animals productive for longer. Consequently, at herd scale, the annual average milk yield of a long productive lifespan system is lower than in the medium or short lifespan production when the extensification effect outweighs the physiological effect. Table 2 shows, this is indeed the case for all systems except for Simmental (**SI** in scenario codes) lower mountain, organic (**SI-LM-O**), Swiss Fleckvieh (**SF** in scenario codes) lower mountain, conventional (**SF-LM-C**), and Holstein (**HO** in scenario

codes) lowland and hill, conventional (**HO-LH-C**), where herd-level milk increases with longer, indicating that physiological gains outweigh the extensification effect.

Feed Intake. Evidence suggests that differences in productive lifespan are influenced by farm management practices, including diet (Dallago et al., 2021; De Vries and Marcondes, 2020; M. Lozano-Jaramillo, A. Bieber, F. Leiber, M. Walkenhorst, and R. C. Eppenstein [Research Institute of Organic Agriculture FiBL, Frick, Switzerland], unpublished data). High-performance dairy cows with a high concentrate intake tend to develop health issues earlier in life compared with lower-performance cows that rely less on concentrates (Flach et al., 2021). Therefore, it is essential to recognize that cows with varying productive lifespans were fed differently. To capture the feeding differences across agricultural zones, breeds, and production systems, feeding ratios for each individual scenario were developed (see Table 3). These feeding ratios were based on an on-farm survey conducted in a total of 63 farms with long ($n = 35$) and short ($n = 28$) productive lifespans (Table 2). These farms belonged to a previously used pool of farms that aimed to find representative farms for Switzerland (Bieber et al., 2024). These feeding ratios were used as input for the FarmLCA feed planner, where roughages were fed according to the reported ratios, and concentrates (both protein-based and energy-based) were adjusted to the production level of each farm, accounting for the different lactation stages (dry, early, mid, and end of lactation). For the medium lifespan representative farms, the average feed between short and long was used as a first starting point in the diet. Replacement animals were mainly fed roughage available on the farm, and calves were given fresh milk in the organic system, which decreased the volume of produced milk on farm and milk replacers in the conventional system.

Feed and Fodder Yields and Their Resulting Land Use. The virtual representative farms were set up to produce roughage on-site differentiating between conventional and organic production, but no data were available on yield in the different agricultural zones, especially concerning grasses. Additionally, it was unclear whether

Table 3. Feed ratio percentages resulting from the feed intake on-farm survey (n = 67)

Agricultural zone	Productive lifespan	Breed	Production system	Grazing	Fresh cut grass in barn	Hay	Maize silage	Grass silage	Concentrate	Energy-based concentrate	Protein-based concentrate	Other feed	Number of farms in survey
Lowland and hill	Short	BV	C	25.2	10.4	32.7	9	10	2.7	5.6	3.6	1	5
		HO	C	20.5	0.2	25.9	21.8	15.3	4.3	2.2	2.5	7.4	6
Lower mountain	Long	BV	C	15.8	7.2	25.6	21.8	12.7	7.5	1.2	1.9	4.7	10
		HO	C	23.2	7.4	27.1	17.2	12.3	7.6	6.7	1.3	1.4	8
	Short	BV	C	27.1	4.1	45	2.1	4.6	3.3	4	1.1	8.9	4
		SF	C	43.6	7.4	37	0	1.5	1.5	4.6	2.5	2.1	6
Upper mountain	Long	SI	O	45.3	0	37.5	0.7	10.6	5.3	0	0	0.8	3
		BV	C	29.8	6.05	34.8	5.2	19.6	1.9	1.95	0.4	0.6	8
		SF	C	46.2	5.25	33.2	2.8	6.1	4	2	0.65	0	5
	Short	SI	O	38.1	0	42	5.3	10.4	4.2	0	0	0	1
		BV	O	57.5	0	35	0	0	2.5	2.5	2.5	0	2
		SI	O	42.4	0	39.5	0.2	16.3	1.6	0	0	0	2
Long	Long	BV	O	51.5	0	45	0	0	1	2.5	0	0	1
		SI	O	44.2	0	43.4	2.5	8.8	1.3	0	0	0	2

the grass specified in the on-farm survey came from temporary or permanent grasslands.

As alternative, yield estimates were taken from the ecoinvent LCA inventory, which reports separate values for organic and for conventional production. These system-specific baselines were used for the lowland and hilly zones. For mountain zones with less favorable climates, system-specific adjustments were applied using scaling factors derived from FAO and IIASA (2011), agro-ecological potentials for maize and grasses.

Accordingly, temporary grassland yields were reduced by 12% in the lower mountain zone and by 60% in the upper mountain zone. Permanent grassland yields were reduced by 19% in the lower mountain zone and by 60% in the upper mountain zone. The grass yields computed in this manner correspond to approximately 3 cuts per year in the lower mountain zone and 2 cuts per year in the upper mountain zone (Jeangros and Thomet, 2004). Maize silage yields were reduced by 46% in the lower mountain zone; however, no adjustment was required for the upper mountain zone, as maize silage is not used there.

To address the split between temporary and permanent grassland, the representative farms were matched with Swiss open statistical data (Hoop et al., 2023) to derive the share of temporary grassland in grass production per farming type. This percentage was then applied to each farm to determine the source of grass production.

Implicit land use was derived from the total annual requirement for forage and maize silage. Diets for each virtual representative farm were aggregated to herd-level dry matter quantities. The grass portion was split into temporary and permanent grassland then each share was divided by the corresponding system (organic or conventional) and zone-specific representative yield to obtain area. Maize silage demand was divided by the system- and zone-specific maize silage yield to obtain area (see Appendix Table A3 for total areas).

Land Savings from Lifespan Extension. Changes in productive lifespan affect the number of replacement animals required and, consequently, the total land demand for feed production. For each scenario, the land saved through lifespan extension was calculated relative to the short-lifespan baseline within the same production zone. Two alternative scenarios were evaluated for the potential use of land saved through extending the productive lifespan. An ecological compensation scenario, where the saved land is assumed to remain in agricultural use and generate subsidy payments per hectare, according to agri-environmental payment schemes (see Appendix Table A2). In the second scenario, saved land is translated into additional dairy production units so the model scales to the available land, indicating that freed area could support additional animals (see Appendix Table A3). The additional income corresponds to the direct margin

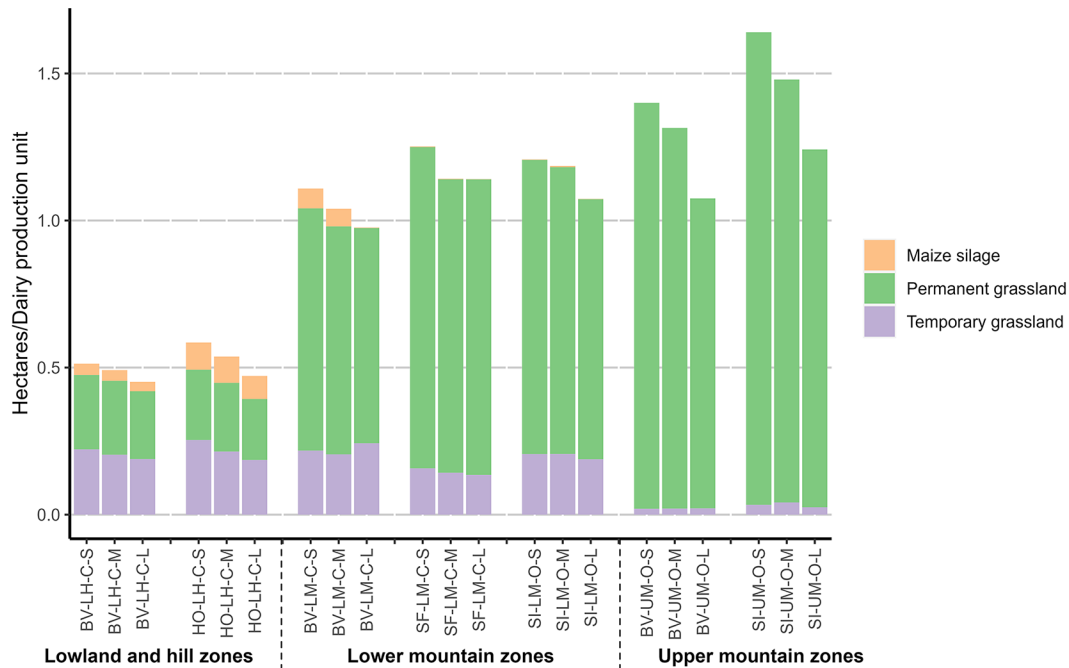


Figure 2. Land use per dairy production unit (a cow including replacements) for the representative farming system with short, medium, and long productive lifespan by land use type. BV = Braunvieh; SF = Swiss Fleckvieh; SI = Simmental; LH = lowland and hill; LM = lower mountain; UM = upper mountain; C = conventional; O = organic; S = short; M = medium; L = long.

generated by the increase of the dairy production unit that can be supported on the saved land. In both cases, the potential added income is calculated on a yearly basis and expressed per dairy production unit.

RESULTS

Land Use

Figure 2 shows local land requirements per dairy production unit, which capture the replacement and feed effects. Only land used for forages grown on the farm is included; land embodied in purchased concentrates, typically sourced outside the farm, is not accounted for in this calculation. Across all breeds and zones, longer productive lifespans resulted in reduced local land use per dairy production unit, reflecting the replacement effect: fewer replacement animals required less total forage area to support the herd. The feed effect was less pronounced, as ration composition and total feed requirements shifted only modestly with lifespan extension. Differences between zones were more substantial. In lowland systems, land use per dairy production unit was the lowest, averaging below 0.6 ha, which was supported by the inclusion of maize silage and temporary grassland. In mountain systems, land requirements were considerably higher, often exceeding 1.0 ha per dairy production unit and reaching 1.5 ha in upper mountain Simmental

organic herds. These systems relied almost exclusively on permanent grassland, illustrating that more extensive, forage-based production in mountain zones requires substantially more land per dairy unit than lowland systems (see Appendix Table A2 for changes in area).

GHG Emissions

Figure 3 shows GHG emissions per dairy production unit, which capture the replacement and feed effects of extending productive lifespan. Emissions are displayed for short, medium, and long productive lifespans, separated by source. Enteric fermentation accounted for more than half of the total emissions across all systems, followed by feed- and manure-related emissions. Despite differences between farming types, total emissions per dairy production unit were relatively similar across systems but tended to be lower in the more extensive organic systems.

Across all breeds and zones, dairy production units of virtual representative farms with a longer productive lifespan exhibited lower emissions than those with a shorter lifespan. The decline from short to long was most pronounced in Braunvieh herds (BV in scenario codes) in lower mountains (BV-LM-C). In Braunvieh lowland herds (BV-LH-C), emissions for medium were slightly higher than for long, whereas in Swiss Fleckvieh in the lower mountain zone (SF-LM-C) medium and long were nearly identical, with long marginally

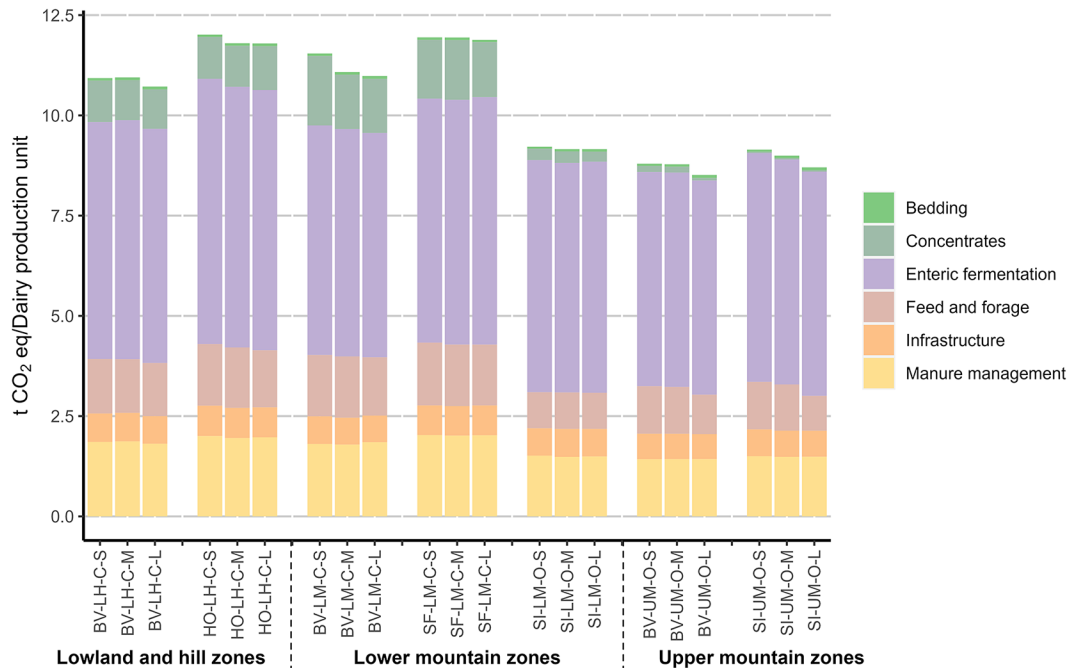


Figure 3. Greenhouse gas emissions per dairy production unit (a cow including replacements) for the representative farming system with short, medium, and long productive lifespans by source of emission. BV = Braunvieh; SF = Swiss Fleckvieh; SI = Simmental; LH = lowland and hill; LM = lower mountain; UM = upper mountain; C = conventional; O = organic; S = short; M = medium; L = long.

lower. In the upper mountain zones in both Braunvieh (BV-UM-O) and Simmental (SI-UM-O) herds, the decline from short to long was clearer.

Figure 4 reports GHG emissions per tonne of milk, which combine replacement feed and milk effects. Enteric fermentation dominates across all systems, whereas feed and forage and manure management are secondary and infrastructure bedding and concentrates are smaller. Emissions generally fall from short to medium to long lifespan. Clear declines appear in Braunvieh (BV-LH-C) and Holstein (HO-LH-C) herds in the lowland and hill zones, Braunvieh (BV-LM-C), Swiss Fleckvieh (SF-LM-C), and Simmental herds (SI-LM-O) in the lower mountain herds, and Simmental (SI-UM-O) herds in the upper mountain zones. Braunvieh herds in upper mountain zones (BV-UM-O) showed only modest drops. The largest reduction is observed for Simmental in the lower mountain zone where the short class is markedly higher than medium and long lifespans (SI-LM-O).

Figure 5 shows GHG emissions per tonne of protein, which captures the combined effects of replacement, feed, milk, and meat. Across all breeds and zones, the lowest emissions were observed in the scenarios with the longest lifespan. Most breeds showed a steady decline in emissions from short to medium to long productive lifespans. The largest reductions are observed for Swiss Fleckvieh in the lower mountain zone (SF-LM-C) and both niche breeds Simmental in the lower and upper

mountain zones (SI-LM-O and SI-UM-O, respectively). The gains from reduced replacement needs, altered feed intake, and sustained milk production outweighed the loss of beef protein from culling. In contrast, Braunvieh herds in the upper mountain zones (BV-UM-O) is the only scenario where the medium productive lifespan had slightly highest emissions. This is because the reduction in milk and meat production outweighs the benefits of lower replacement needs when moving from short to medium lifespan. Nevertheless, the long productive lifespan still yields the lowest emissions, as the gain from an overall smaller animal population in the system outweighs the remaining loss in milk and meat output relative to the short and medium scenarios.

Economic Farm Performance

Figure 6 presents the cost and revenue components of the gross margin calculation per dairy production unit for the representative farms, differentiated by productive lifespan. Several cost categories declined with longer productive lifespans. Most notably, costs for replacement animals, concentrates, and bedding decreased, reflecting the lower number of replacements required. Other costs, including veterinary treatments, minerals, and milk testing, showed no consistent pattern, with some systems reporting lower values and others higher at longer lifespans, depending on the level of milk production.

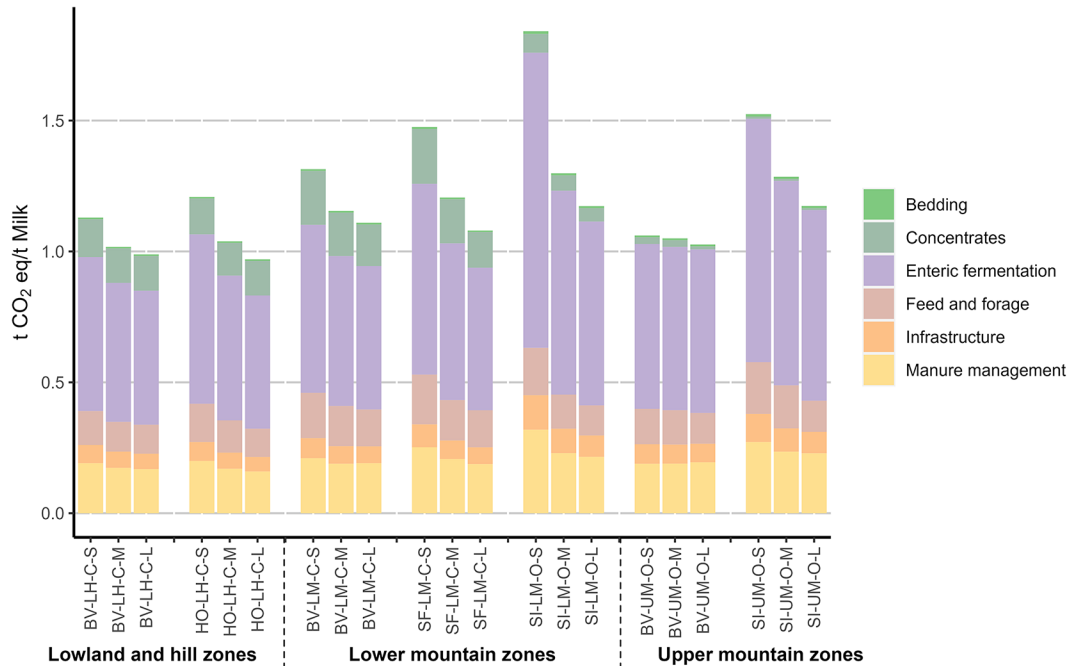


Figure 4. Greenhouse gas emissions per tonne of produced milk for the representative farming system with short, medium, and long productive lifespan by source of emission. BV = Braunvieh; SF = Swiss Fleckvieh; SI = Simmental; LH = lowland and hill; LM = lower mountain; UM = upper mountain; C = conventional; O = organic; S = short; M = medium; L = long.

On the revenue side, extending the lifespan consistently increased income from calves sold for fattening, as fewer heifers were retained for replacement purposes. Conversely, revenues from culled dairy cows decreased, as culling occurred later. Milk revenues varied with breed and production system, depending on whether longer lifespans were associated with higher or lower herd-level yields (see Table 2).

Overall, gross margin contributions of a dairy cow production unit showed that, in most systems, the medium productive lifespan scenario provided the highest profitability. An exception was observed in Swiss Fleckvieh herds in the lower mountain zone, where gross margin was highest in the long scenario due to gains in milk revenue outweighing the additional feed costs.

Results are reported for short, medium, and long lifespans and for 2 alternative assumptions about how the land saved through lifespan extension is used: (1) receiving payments through agri-environmental schemes on the freed land (Figure 7a) or (2) using the freed land to add additional dairy production units (Figure 7b).

In the case where saved land generated additional direct payments for agri-environmental schemes (Figure 7a), the potential income is typically highest for long productive lifespans with only marginal difference between medium and long in few cases such as BV-LH-L, where the difference in potential resulting income between the medium and long was marginal. When saved

land is instead used to add additional dairy production units (Figure 7b), the potential added income is consistently larger and is highest under long productive lifespans across all systems. Overall, once the valorization of freed land is accounted for, the long productive lifespan tends to be the most profitable option for farmers under both land-use assumptions.

DISCUSSION

This study evaluated how extending the productive lifespan of dairy cows affects GHG emissions, land use, and farm economics across Swiss systems varying by breed, zone, and production system. Using life cycle assessment with short, medium, and long productive lifespans, results showed that longer-lived cows consistently reduced emissions and land use, mainly by lowering the need for replacement animals, with per-tonne milk emissions declining even under lower milk yields. Longer productive lifespans outperformed shorter ones across all environmental metrics, and organic or extensive systems were as efficient as intensive ones. In addition, the niche systems (SI-LM-O and SI-UM-O) show only marginally higher emissions than the dominant breed options within the same agricultural zone under long productive lifespans, indicating that these systems remain viable options for transformation pathways that maximize livestock production based on feed resources

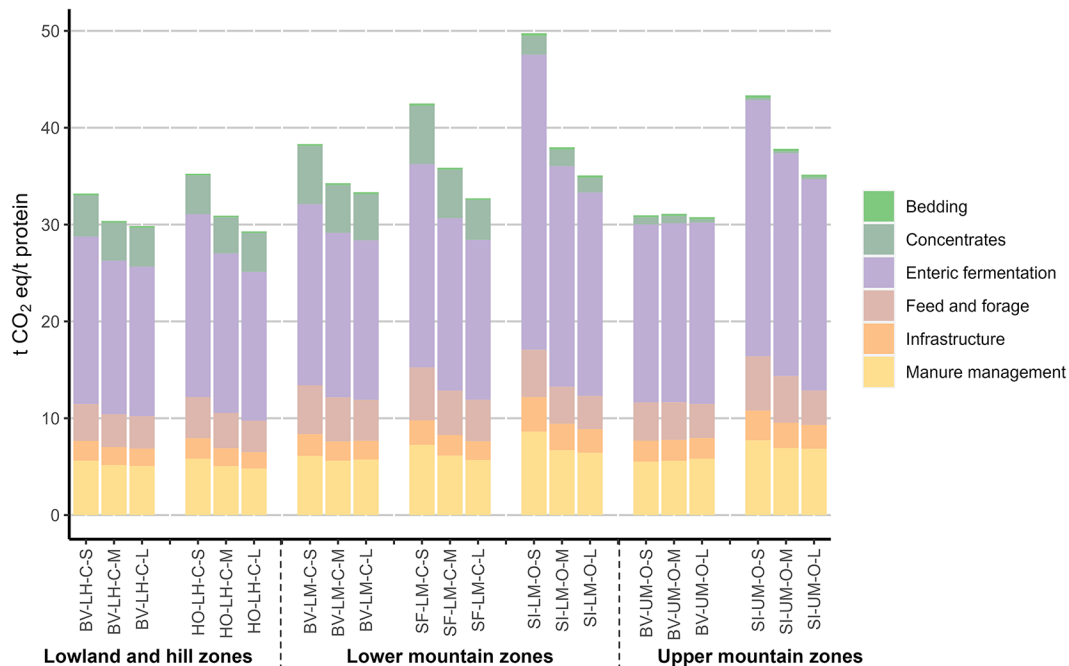


Figure 5. Greenhouse gas emissions per tonne of protein produced for the representative farming system with short, medium, and long productive lifespans by source of emission. BV = Braunvieh; SF = Swiss Fleckvieh; SI = Simmental; LH = lowland and hill; LM = lower mountain; UM = upper mountain; C = conventional; O = organic; S = short; M = medium; L = long.

that do not compete with human nutrition. Economically, medium lifespans currently yield the highest gross margins, but profitability could improve by maintaining healthier cows through later lactations and by reallocating land freed from replacements to other uses, such as ecological measures or increased livestock numbers. Overall, extending productive lifespan enhances environmental sustainability and presents opportunities to increase farm-level economic returns.

Comparing Effects on GHG Emissions Across Functional Units

Emission outcomes can be understood as the interaction of 4 mechanisms—replacement, feed, milk, and meat effects—which accumulate across the functional units considered. These functional units offer a mechanistic perspective but do not encompass product-level carbon footprints. Across all metrics, long productive lifespans performed better than short ones, confirming longevity as a robust strategy for reducing GHG emissions and land use. In line with these findings, a recent study that analyzed the effects of implementing the Swiss voluntary program to promote longevity in dairy cows concluded that such a policy can lead to a 1.7% reduction in total GHG emissions (Winter et al., 2024).

At the cow level, the need for less replacement consistently reduced emissions; however, in some systems,

the feed effect partly offset this gain, resulting in only marginal reductions. When considering the milk effect, there is a robust decline in GHG emissions per tonne of milk across all breeds and zones, particularly in dual-purpose niche breeds. This indicates that in dual-purpose systems, changes in productive lifespan affect both milk and meat outputs in proportionally greater amounts, thereby reducing the risk of unfavorable trade-offs between replacement rates and production levels. This is a notable finding, as emissions per tonne of milk decreased even when milk yields declined due to the extensification effect. In other words, no negative feedback occurred: prolonging productive lifespan consistently reduced the CO₂ intensity per tonne of milk. At the protein level, for almost all breeds and zones the reduction in GHG emissions is larger than the loss in animal protein output associated with lower meat production. The only exception is Braunvieh organic in the upper mountain (BV-UM-O), where emissions per unit of protein are highest under the medium (current) lifespan and lower under both short and long lifespans. This non-monotonic pattern suggests that, once the meat effect is accounted for, the emission outcome per unit of protein can depend on whether lifespan extension coincides with a stronger extensification effect and a disproportionate reduction in yields in this specific system.

A further key result is that extensive and organic systems were not less climate-efficient than intensive lowland

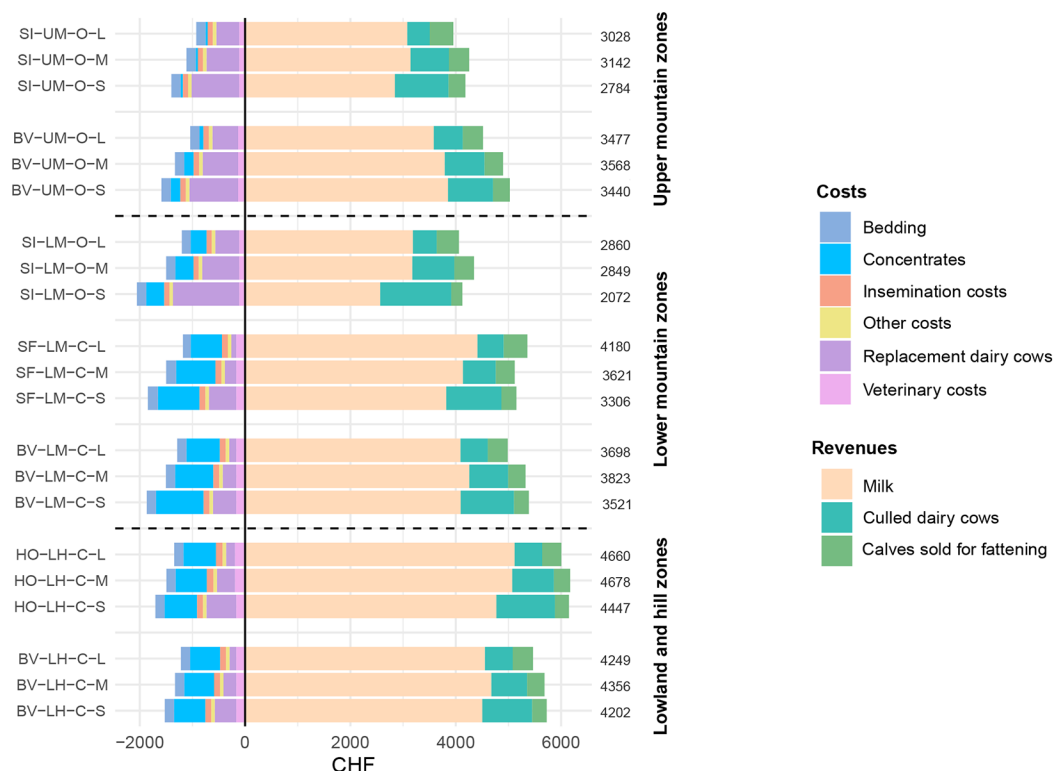


Figure 6. Costs and revenues per dairy production unit (a cow including replacements) included in the gross margin calculation for representative farms with short, medium, and long productive lifespans. Numbers to the right of each bar indicate the resulting net margin (CHF per dairy production unit). BV = Braunvieh; SF = Swiss Fleckvieh; SI = Simmental; LH = lowland and hill; LM = lower mountain; UM = upper mountain; C = conventional; O = organic; S = short; M = medium; L = long.

systems when assessed on a per-dairy-production-unit and per-ton-of-milk basis. Organic virtual representative farms show lower GHG emissions at unit level because herd live weight is lower, which reduces enteric and manure emissions, yet they also produce less milk. It is therefore notable that per tonne of milk, emissions are not higher in these systems, which align with meta-analyses reporting lower impacts per unit area and similar climate effects per unit mass in organic compared with conventional systems (Hashemi et al., 2024). In the present analysis, this outcome is the result of the assumption made on about the feed sourcing: Organic herds relied almost entirely on local forage, whereas conventional herds used more concentrates, including soybean meal assumed to originate from Brazil. Because emissions from land-use change are included for the soy from Brazil, concentrate-rich rations lost much of their apparent advantage, and organic systems performed comparably—or even better in some cases—on a per-tonne basis.

Economic and Land Use Implications

The gross margin analysis indicated that the representative farms with shorter lifespans have the lowest gross

margin across all virtual representative farms. Meanwhile, the representative farms with a medium lifespan tended to have the highest gross margin, with long lifespans only outperforming in specific contexts such as Swiss Fleckvieh in the lower mountain zone when not accounting for the valorization of freed land. This suggests that extending lifespans beyond current practice does not necessarily increase gross margin, even though the cost of rearing reduces. Gains at longer lifespans depend on sustaining yields in later lactations and on maintaining animal health and fertility to avoid rising veterinary or opportunity costs. Recent research has shown that cows reaching a higher number of lactations do so not because of increased veterinary interventions, but because they are healthier animals (Bieber et al., 2024). This finding highlights that improvements in animal health are a crucial pathway toward achieving longer and more productive lifespans. Moreover, extending the productive lifespan of dairy cows can increase farm profitability by 10% to 15%, provided that stable and trouble-free production is maintained, regardless of the actual lactation performance (Gazzarin et al., 2025). Also 40% of Swiss dairy cows leave the herd before completing a second lactation (Schlebusch et al., 2024). Extending produc-

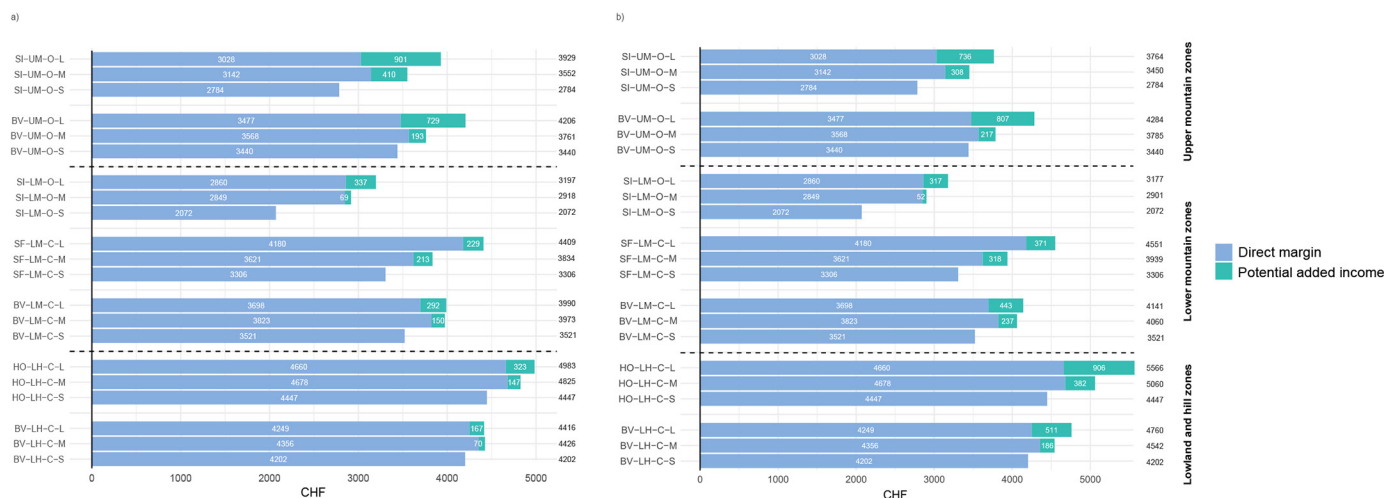


Figure 7. Yearly direct margin and potential additional income per dairy production unit (one cow including replacements) for representative farms with short, medium, and long productive lifespans. Two cases are shown for potential uses for the land saved by extending the productive lifespan: (a) agri-environmental scheme payments are received per hectare saved, or (b) the saved land is used to keep additional animals. Numbers to the right of each bar indicate the total resulting potential income (CHF per dairy production unit). BV = Braunvieh; SF = Swiss Fleckvieh; SI = Simmental; LH = lowland and hill; LM = lower mountain; UM = upper mountain; C = conventional; O = organic; S = short; M = medium; L = long.

tive life, therefore, does not mean keeping all dairy cows longer, but rather reducing early culling and enabling more animals to pass the first lactation, where the largest physiological gains in milk production can be achieved without necessarily requiring system extensification. Such improvements offer opportunities at the farm level to increase both lifetime milk production and productive lifespan, thereby improving profitability.

Productive lifespan also has implications for land use because fewer replacement heifers reduce youngstock feed demand and can free land, a benefit that is not captured in the direct margin per dairy production unit. Although the direct margin per dairy production unit captures the reduction in rearing costs associated with a lower replacement rate, it does not capture the additional economic value that may be generated from the freed land. Once the valorization of freed land is considered, the economically preferred response becomes farm-specific because the land gain is not uniform. Land is released from the holding only when replacement rearing is carried out on-farm; in that case, the profitability effect depends on how the freed area can be used and on binding capacity constraints. One scenario explored here is to use freed land to add additional dairy production units, which is only feasible where housing, labor and milking capacity allow for an expansion. By contrast, enrolling freed land in agri-environmental payment schemes is, in principle, available to any farm that frees land. Beyond these stylized options, cropland alternatives include shifts toward higher-return cash crops, whereas grassland could also be used to fatten dairy-born offspring beyond the calf stage, increasing

dairy-coupled meat provision (Pfeifer et al., 2025) and can reduce GHG (Zehetmeier et al., 2012).

However, on many Swiss dairy farms, replacement rearing is spatially separated from milk production through contract rearing arrangements between lowland dairy farms and mountain rearing farms (Marton et al., 2016). In such setups, a lower replacement rate still reduces rearing costs for the dairy farm, but this cost saving alone, in most cases, does not compensate for the reduction in meat-related income associated with fewer replacement animals. Yet it does not release land on the milk-producing farm, as rearing takes place somewhere else. Any land-use effects instead occur in the rearing region, where lower replacement demand may reduce land requirements or management intensity. System-level benefits, therefore, still arise, even if the land-related benefit is not captured on the dairy farm. This spatial separation, therefore, creates a distributional challenge: the actor implementing management changes to extend lifespan is not always the actor capturing the land-related benefit. Policies promoting longer productive lifespans should therefore consider where benefits arise and how they are shared along the production chain.

Limitations and Future Research

The first set of limitations concerns technical assumptions. The analysis was based on representative Swiss farms defined by zone, breed, and production system, rather than measured case farms; this strengthens comparability but limits external validity beyond Switzerland. Several boundary choices are important for interpreting

the results. Replacement rearing was assumed to occur on-farm, and surplus calves were assumed to leave at 28 d; these choices simplify herd dynamics but may underestimate the variability in rearing systems. Manure was modeled as a mixed system, whereas regional variation in housing and storage practices could lead to different emission profiles. Also, grass yields were estimated by scaling inventory data with agri-ecological factors, and the split between temporary and permanent grassland was based on national statistics, which does not represent differences in management of the grassland and introduces uncertainty in systems with more heterogeneous land use. Furthermore, animal diets were derived from a targeted survey with relatively small strata, which may not capture the full diversity of practices, yet given the little amount of data available, this approach made it possible to account for the fact that systems with short or long productive lifespans have different feeding strategies that actually correlate with animal health and their productive lifespan. Finally, the results proved sensitive to milk-to-feed price ratios, cull-cow prices, and the choice of functional unit, underscoring that both market conditions and allocation rules significantly influence emission and profitability outcomes.

Beyond these technical considerations, extending productive lifespan is not just a matter of choice. Factors influencing longevity include health, fertility, management (De Vries, 2020; Bieber et al., 2024), but also economic choices (Gazzarin et al., 2025) and breeding system conventions which make up a complex matrix of conditions. Recent developments show trends to increase longevity (Bieber et al., 2026) after decades of decline (Knaus, 2009), demonstrating the challenge and the potential, though.

Because longer productive lifespans reduce the number of culled cows, meat output from dairy herds declines. This raises the possibility of consequential effects at the food-system level: Reduced dairy-beef availability could lead to increased production from other sources, such as suckler cows, which may partly offset the environmental gains from longevity. Assessing these interactions requires system-expansion analyses that consider how changes in dairy herd dynamics affect overall meat supply and emissions. Understanding these consequences is essential to ensure that prolonging dairy cow lifespan does not produce unintended increases in other, less efficient forms of beef production.

Future research should therefore move beyond herd-level analysis and adopt a broader perspective on the food system. A key priority is to evaluate the consequences of reduced beef output from longer productive lifespans, including how this meat loss may be compensated. It will be essential to identify substitution pathways with the lowest possible emissions. In parallel, the potential uses

of land freed by reduced replacement rearing require closer examination. Such land could be directed toward biodiversity and nitrogen regulation, providing environmental co-benefits, or allocated to additional animal production, which could erode or even negate the climate advantages of longevity. Exploring these alternative land-use pathways and their system-level consequences is therefore essential to ensure that herd-level gains in GHG efficiency translate into genuine benefits for the food system as a whole.

CONCLUSIONS

Extending the productive lifespan of Swiss dairy cows consistently reduces GHG emissions and land use per tonne of milk, supporting climate and biodiversity goals. The greatest reductions occur when longer lifespans align with higher milk yields, but even under more extensive conditions with lower yields, environmental efficiency improves. Per kilogram of protein, results are more variable. Specialized dairy breeds see limited gains due to reduced beef output, whereas dual-purpose breeds maintain steady improvements. Longer lifespans offer economic benefits, especially for dairy farms that rear their own replacement animals, which can valorize the freed land. Yet, even for other systems, there can be economic benefits as short-lived cows yield the lowest gross margins, and many animals are culled before the second lactation, highlighting potential for increased profitability and sustainability through improved health and management. The main challenge is offsetting reduced meat production without undermining climate benefits. Future research should adopt a food system perspective, exploring substitution pathways for beef and alternative uses of land saved by lower replacement rearing, ensuring herd-level benefits translate into system-level sustainability gains.

NOTES

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Nonstandard abbreviations used: CHF = Swiss franc; LCA = life cycle assessment, LCI = life cycle inventory, DM = dry matter, LH = lowlands and hills, LM = lower mountain, UM = upper mountain, CH₄ = methane, N₂O = nitrous oxide, FU = functional unit, BV = Braunvieh, HO = Holstein, Q1–Q4 = first to fourth quartiles; SF = Swiss Fleckvieh, SI = Simmental.

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APPENDIX

Table A1. Costs, revenues, and dressing percentages assumed for the gross margin calculation¹

Type	Category	Subcategory	Unit	Conventional	Organic
Revenue	Output price milk		CHF/kg	0.65	0.82
	Output price meat old cow		CHF/kg CW	8.4	8.4
	Output price calf for fattening		CHF/kg AW	8.1	8.1
Costs	Replacement cost dairy cow	Cow with milk yield 5,000 kg	CHF/animal	2,600	2,600
	Replacement cost dairy cow	Cow with milk yield 6,000 kg	CHF/animal	2,800	2,800
	Replacement cost dairy cow	Cow with milk yield 7,000 kg	CHF/animal	3,000	3,000
	Replacement cost dairy cow	Cow with milk yield 8,000 kg	CHF/animal	3,300	3,300
	Replacement cost dairy cow	Cow with milk yield 9,000 kg	CHF/animal	3,600	3,600
	Insemination cost	Cow with milk yield 5,000 kg	CHF/animal	112	98
	Insemination cost	Cow with milk yield 6,000 kg	CHF/animal	112	105
	Insemination cost	Cow with milk yield 7,000 kg	CHF/animal	112	112
	Insemination cost	Cow with milk yield 8,000 kg	CHF/animal	126	126
	Insemination cost	Cow with milk yield 9,000 kg	CHF/animal	126	126
	Veterinary cost	Cow with milk yield 5,000 kg	CHF/animal	165	110
	Veterinary cost	Cow with milk yield 6,000 kg	CHF/animal	165	130
	Veterinary cost	Cow with milk yield 7,000 kg	CHF/animal	165	140
	Veterinary cost	Cow with milk yield 8,000 kg	CHF/animal	190	140
	Veterinary cost	Cow with milk yield 9,000 kg	CHF/animal	200	140
	Protein based concentrate cost		CHF/kg	0.96	1.3
	Energy based concentrate cost		CHF/kg	0.85	1.2
	Milk replacement for calves cost		CHF/kg	4.8	
	Other costs	Conventional cow with milk yield 7,000 kg	CHF/animal	66	
	Other costs	Conventional cow with milk yield 8,000 kg	CHF/animal	66	
	Other costs	Conventional cow with milk yield 9,000 kg	CHF/animal	66	
	Other costs	Organic cow with milk yield 5,000 kg	CHF/animal		66
	Other costs	Organic cow with milk yield 6,000 kg	CHF/animal		66
	Other costs	Organic cow with milk yield 7,000 kg	CHF/animal		66
Dressing percentage for CW	Dressing percentage	Old cow 7,000 kg milk yield	Percentage	0.46	
	Dressing percentage	Old cow 8,000 kg milk yield	Percentage	0.45	
	Dressing percentage	Old cow 9,000 kg milk yield	Percentage	0.45	
	Dressing percentage	Old organic cow 5,000 kg milk yield	Percentage		0.48
	Dressing percentage	Old organic cow 6,000 kg milk yield	Percentage		0.48
	Dressing percentage	Old organic cow 7,000 kg milk yield	Percentage		0.46

¹CW = carcass weight; AL = alive weight; CHF = Swiss franc.**Table A2.** Area of land saved and corresponding additional potential income from agri-environmental payments when extending the productive lifespan of dairy cows from short to medium and from short to long across different scenarios¹

Scenario	Land saved of PG in short to long (ha)	Land saved of PG in short to medium (ha)	Land saved of TG+M in short to long (ha)	Land saved of TG+M in short to medium (ha)	Additional potential income long (CHF)	Additional potential income medium (CHF)
BV-LH-C	0.022	0.001	0.039	0.021	167	70
HO-LH-C	0.031	0.006	0.082	0.042	323	147
BV-LM-C	0.092	0.049	0.041	0.020	292	150
SF-LM-C	0.087	0.095	0.024	0.015	229	213
SI-LM-O	0.116	0.025	0.018	0.003	337	69
BV-UM-O	0.326	0.086	0.001	0.001	729	193
SI-UM-O	0.390	0.169	0.008	0.008	901	410

¹Land savings are reported for permanent grassland (PG) and temporary grassland plus maize silage (TG+M) in hectares per dairy production unit. Additional potential income is calculated based on Swiss agri-environmental payment rates of Swiss francs (CHF) 1,731/ha (conventional) and CHF 2,215/ha (organic) for permanent grassland ("Naturwiese extensiv/Hecke," Agridea, 2023), and CHF 3,268/ha (conventional) and CHF 4,462/ha (organic) for temporary grassland and maize silage ("Buntbrache," Agridea, 2023). Income values represent the theoretical maximum additional payments associated with the land saved in each scenario.

Table A3. Percentage of land saved and number of additional dairy cows that could be accommodated in the herd by extending the productive lifespan from short to medium and from short to long in different scenarios¹

Scenario	Total area short (ha)	Total area long (ha)	Total area medium (ha)	Land saved short to long (%)	Land saved short to medium (%)	Additional potential cows in long	Additional potential cows in medium	Additional potential income long (CHF)	Additional potential income medium (CHF)
BV-LH-C	0.51	0.45	0.49	12.02	4.28	3.5	1.2	511	186
HO-LH-C	0.59	0.47	0.54	19.44	8.16	6.0	2.5	906	382
BV-LM-C	1.11	0.98	1.04	11.97	6.21	2.4	1.2	443	237
SF-LM-C	1.25	1.14	1.14	8.87	8.77	1.8	1.8	371	318
SI-LM-O	1.21	1.07	1.19	11.09	1.82	1.8	0.3	317	52
BV-UM-O	1.40	1.08	1.31	23.21	6.09	3.9	1.0	807	217
SI-UM-O	1.64	1.24	1.48	24.29	9.80	3.4	1.4	736	308

¹Total land area (ha) refers to the area required to support the herd under each lifespan scenario. Land saved is expressed as the relative reduction in total area compared with the short lifespan scenario. Additional cows represent the maximum potential increase in herd size that could be supported on the same land due to the increase in productive lifespan. CHF = Swiss franc.