How to meet strong sustainability in dairy farming an exploratory approach using ecological accounting

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Plan

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4- Conclusion

Why does this study matter?

- 6 of the 9 planetary boundaries have been crossed due to human activities

- Major role of agriculture & livestock farming (Bowles et al., 2019; Campbell et al., 2017)

- Strong sustainability conceptual framework to guide actions (Solow, 1993)

  Natural capital should be preserved independently of other types of capital

  No substitution possible between natural and other forms of capital

- Assess the environmental impact of agriculture from a strong sustainability perspective

Main contribution

- Assess costs associated with environmental performance of dairy farms
- Focus on two critical natural capitals: **climate** and **biodiversity**

- Methodology

  Use linear mixed-effects model to estimate the costs associated with GHG reduction and biodiversity preservation

  Apply the CARE (Comprehensive Accounting in Respect of Ecology) method to integrate the environmental costs into ecological accounting to reflect their impact on farm accounting

- Empirical application

  Analyze a sample of 3,438 dairy farms in Brittany, France from 2018 to 2022

The CARE operational process in four steps (Rambaud and Chenet, 2021)

Identify the natural capitals impacted by agricultural activity → Define preservation indicators and desired levels → Determine preservation actions and their costs → Adjust the balance sheet and income statement in ecological accounting

Classification of farms based on GHG emissions

- GHG emissions (kg CO_2 eq per liter of milk)
- Using the Agribalyse database (ADEME)

  Validation/comparison: benchmarked against CAP'2ER reports from the French livestock institute (Institut de l'élevage)

- Classification aligned with the objectives of the National Low-Carbon Strategy (SNBC)

  Targeted annual reduction: 1.4% in emission levels

  Average emissions of the 2018 sample projected to 2024

  Class 1: Emissions ≤ 1.13 kg CO_2 per liter of milk

  Class 2: Emissions > 1.13 kg CO_2 per liter of milk

2018 (starting year)	**: 1,23**
2019	: 1,23 × 0,986 = 1,21
2020	: 1,21 × 0,986 = 1,19
2021	: 1,19 × 0,986 = 1,17
2022	: 1,17 × 0,986 = 1,16
2023	: 1,16 × 0,986 = 1,14
2024	**: 1,14 × 0,986 = 1,13**

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Classification of farms based on biodiversity

- Biodiversity = Share of temporary grasslands / UAA
- Classification based on sample trends

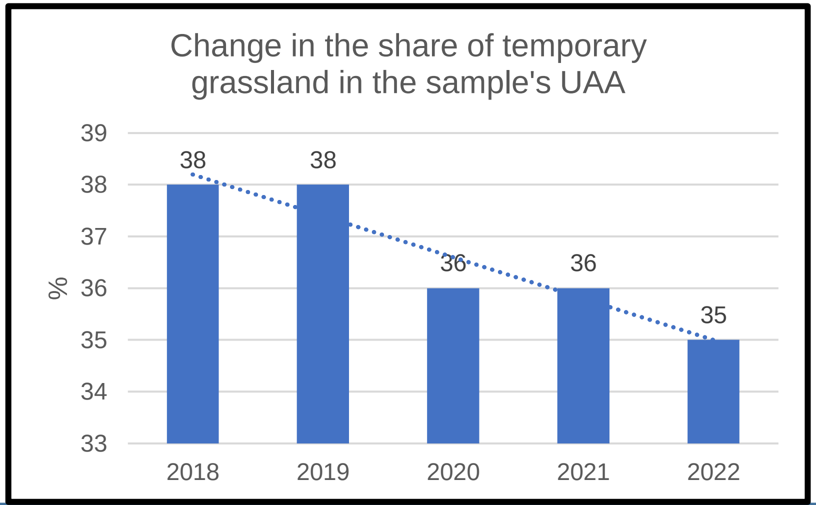
  Observed trend: a decrease in the share of grasslands over the years

  Objective: to slow down this concerning trend

  Constraint imposed: maintained at the sample's average level

  Reference threshold: 38% (average observed in 2018)

  - **Class 1**: Temporary grasslands/UAA < 38%
  - **Class 2**: Temporary grasslands/UAA ≥ 38%



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Econometric approach to calculate natural capital maintenance costs

- Linear Mixed-Effects Model

Isolate specific cost associated with reducing GHG emissions and maintaining a good level of temporary grasslands

Accounting for variability between farms

$$y_{it} = \alpha_0 + \alpha Z'_{it} + \gamma_t + \mu_i + \varepsilon_{it}$$

y_{it} production cost in year t for individual i
γ_t temporal effects
μ_i random individual effects
Z'_{it} explanatory variables vector
ε_{it} residual

→

Class based on emissions
Class based on biodiversity
Size of Utilized Agricultural Area (UAA)
Herd size (Number of cows)
Forage system (< 10%; 10 à 30%; > 30% of maize)
Business type (individual, EARL, GAEC, Others)

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Sample description

- Individual accounting data for specialized conventional dairy farms in Bretagne
- Unbalanced panel of 3,438 farms over 3 years (2018 - 2022)

Indicators	Mean
Emission (kg CO_2 eq/l milk)	1.21
Emission (kg CO_2 eq/ha of UAA)	8,339
Grassland Area / UAA (%)	37
Production Cost (€/1000l)	499
Total AWU (Annual Work Units)	1.85
UAA (ha)	90
Number of Dairy Cows	77
Milk produced (liters)	597,071

Average emission for Brittany using the CAP'2ER Method (2013-2021 – Idele)

- 0.97 kg CO2/liter of milk
- 8,261 kg/ha

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Environmental efforts costs

Variables	Coefficients	Standard errors
Constant	563.20	(4.59)***
GHG emission (≤ 1,13 Kg eq CO_2/l milk)	-6.72	(1.05)***
Temporary grassland/UAA (≥ 38%)	8.43	(1.37)***
Forage system Mostly grass	2.15	(7.34)
Forage system Grass + Corn	10.33	(1.95)***
…	…	…
Random effects	82%	
Number of observations	10,518	
R2	61%	

The CARE operational process in four steps (Rambaud and Chenet, 2021)

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Preservation cost calculation - Reference farm of the model

Indicators	Mean	Standard deviation
Emission (kg CO2 eq/l milk)	1.28	0.10
Grassland Area / UAA (%)	25	10
Production Cost (€/1000l)	480	59
Total AWU	2.44	0.66
UAA (ha)	115	38
Number of Dairy Cows	92	27
Milk produced (liters)	738,065	240,279
Total emission (tons CO2 eq)	945	24

Reference Farm

- Year 2018
- Emissions > 1.13 kg/liter
- Temporary grasslands < 38% of the UAA
- Legal status: GAEC
- Forage system > 30% maize

366 farms

The CARE operational process in four steps (Rambaud and Chenet, 2021)

Identify the natural capitals impacted by agricultural activity → Define preservation indicators and desired levels → **Determine preservation actions and their costs** → Adjust the balance sheet and income statement in ecological accounting

Preservation cost calculation - Reference farm of the model

Objectives for improving natural capital

- Reduce GHG emissions < 1.13 kg CO2 eq/l
- Increase temporary grasslands ≥ 38% of the UAA

Calculation of preservation costs on the sample

Actions	Formula	Result
GHG emissions reduction /l	€6.72 /1000l * 738,065 l / 1000	**Gain of €4,960**
Increase in grassland / UAA	€8.43 /1000l * 738,065 l / 1000	**Cost of €6,222**

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Impacts on the Balance Sheet of the desired preservation actions

Assets	gross	depreciation	net	Liabilities	provision	refund	net
Financial Assets				Financial Capital			
Fixed Assets				Equity			
Current Assets				Loans			
Natural Assets				*Natural Capitals*			
Climate (Emissions avoided)	4,960		4,960	Climate			
Biodiversity (Grassland maintained)		6,222	- 6,222	Biodiversity			
				Adapted income CARE			
TOTAL Assets	+4,960	-6,222	-1,262	TOTAL Liabilities			

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Calculation of the cost of actual preservation actions

Characteristics of **one** dairy farm that does reach the desirable climate dans biodiversity thresholds

Indicators	Mean
Emission (kg CO2 eq/l milk)	1.71
Grassland Area / UAA (%)	25
Production Cost (€/1000l)	442
Total AWU	2
UAA (ha)	97
Number of Dairy Cows	90
Milk produced (liters)	630,074
Total emissions (tons CO2 eq)	1,077

Calculation of the cost of his/her actions

Actions	Formula	Result
GHG emissions reduction	€6.72 /1000l * 630,074l / 1000	Gain of €4,234 €
Increase in grassland	€8.43 /1000l * 630,074 l / 1000	Cost of €5,311€

- Mismatch with the **desired** preservation costs

The CARE operational process in four steps (Rambaud and Chenet, 2021)

Identify the natural capitals impacted by agricultural activity → Define preservation indicators and desired levels → Determine preservation actions and their costs → Adjust the balance sheet and income statement in ecological accounting

Adapted balance sheet

Assets	gross	depreciation	net	Liabilities	provision	refund	net
Financial Assets				Financial Capital			
Fixed Assets				Equity			
Current Assets				Loans			
Natural Assets				*Natural Capitals*			
Climate (Emissions avoided)	4,960		4,960	Climate	4,234		4,234
Biodiversity (Grassland maintained)		6,222	- 6,222	Biodiversity		5,311	-5,311
				Adapted income CARE			*- 185*
TOTAL Assets	+4,960	-6,222	-1,262	TOTAL Liabilities			-1,262

The CARE operational process in four steps (Rambaud and Chenet, 2021)

Identify the natural capitals impacted by agricultural activity → Define preservation indicators and desired levels → Determine preservation actions and their costs → **Adjust the balance sheet and income statement in ecological accounting**

Adapted Income Statement

Sales	
Subsidies	
Biodiversity preservation product	5 311
Climate preservation product	4 990
Operating revenues (variation)	+ 10 271
Purchases	
Current expenses	
Amortization expenses	
Biodiversity renewal expenses	6 222
Climate preservation expenses	4 234
Operating expenses (variation)	+10 456
Adapted Income CARE	*-185*

Conclusion

Consideration of strong sustainability, in contrast to the majority of studies that follow a weak sustainability logic, where the environment is often subordinated to economic efficiency

Efficiency gains help reduce GHG emissions in compliance with the Paris Agreement

Maintaining biodiversity requires additional costs

Exploration of the implementation of CARE accounting

- Requires a large amount of data on agricultural practices
- Assessment of the value of natural capital through an econometric approach

Ecological accounting remains an area of research to be explored in the agricultural sector

Thank You!
Des questions?