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Estimating the Costs of Improving Animal Welfare: A Case Study of Italian Simmental Mountain Dairy Farms

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The Economic Gap

Regulatory expectations for AW are outpacing the economic realities of mountain dairy farming.

Growing Awareness of Animal Welfare

Improving Animal Welfare Standards

Anthropocentric
Cost-Benefit Analysis (CBA)

Non-anthropocentric
Animal Quality-Adjusted Life Year (A-QALY)

Financial Barriers

Methodological Gap

Previous protocols rely on ordinal scales, limiting robust econometric modelling.

Current Protocols

Ordinal scales (e.g., categorizing conditions as insufficient, acceptable, or excellent).

Welfare Quality® Science and society improving animal welfare

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The Measurement Gap

- Lack of precise numerical thresholds.
- Opaque weighting of categorical indicators.
- Vulnerability to skewed scoring, particularly in smaller mountain herds where standard distributions fail.

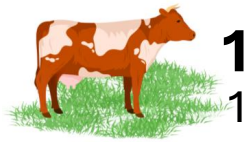
Our Contribution

This study builds upon these continuous scales to empirically correlate "AW Scores" with "AW Costs."

Scan here for AW Protocols and scales

Material

Counterfactual Framework: Despite matched farm structures, key indicators (pasture, MY) inherently diverge due to management.



15 ORG Farms
10 Simmental cows/farm

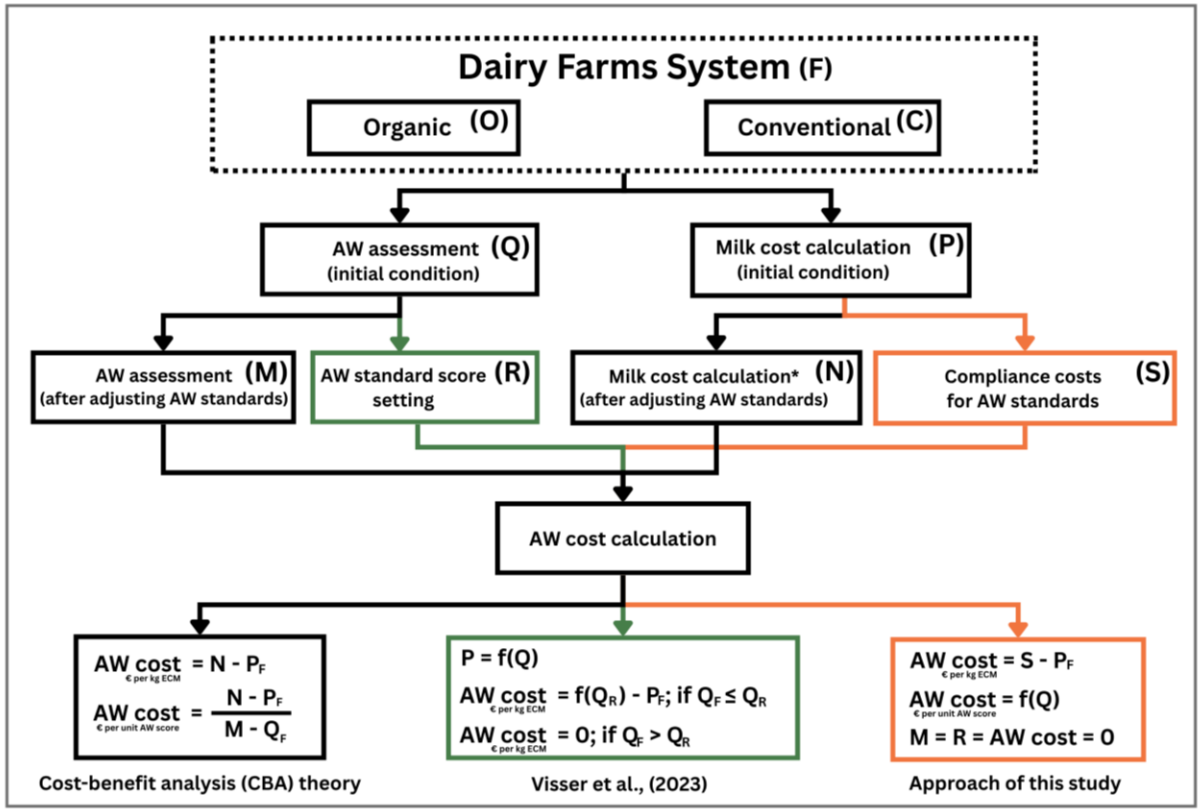
15 CON Farms
10 Simmental cows/farm

FARM CHARACTERISTIC	ORGANIC (MEAN ± SD)	CONVENTIONAL (MEAN ± SD)
Dairy cows (head)	16.10 ± 7.9	17.50 ± 5.2
Calves < 6 month (head)	2.40 ± 1.7	3.70 ± 2.5
Calves 6 - 24 month (head)	3.90 ± 2.9	4.70 ± 2.8
Permanent grassland (ha)	12.40 ± 5.3	12.40 ± 4.9
Days of pasture dairy cows (days/year)	**201.3 ± 36.9**	**25.3 ± 25.7**
Elevation (m a.s.l.)	1,218 ± 189	1,148 ± 246
Milk yield (kg ECM/cow/year)	**6,540 ± 1,336**	**9,505 ± 912**
Stocking rate (LU ha-1)	1.31 ± 0.28	1.53 ± 0.37
Fat (%)	4.015	3.944
Protein (%)	0.035	0.032
Total feed ration (kg DM/cow/day)	**16.365**	**18.109**
Workload Per farm (h/farm/year)	1,332	2,001
Workload Per cow (h/LU/year)	101.53	96.97

Method

The models will tell us the additional cost required to achieve targeted AW standards.

Method of the study

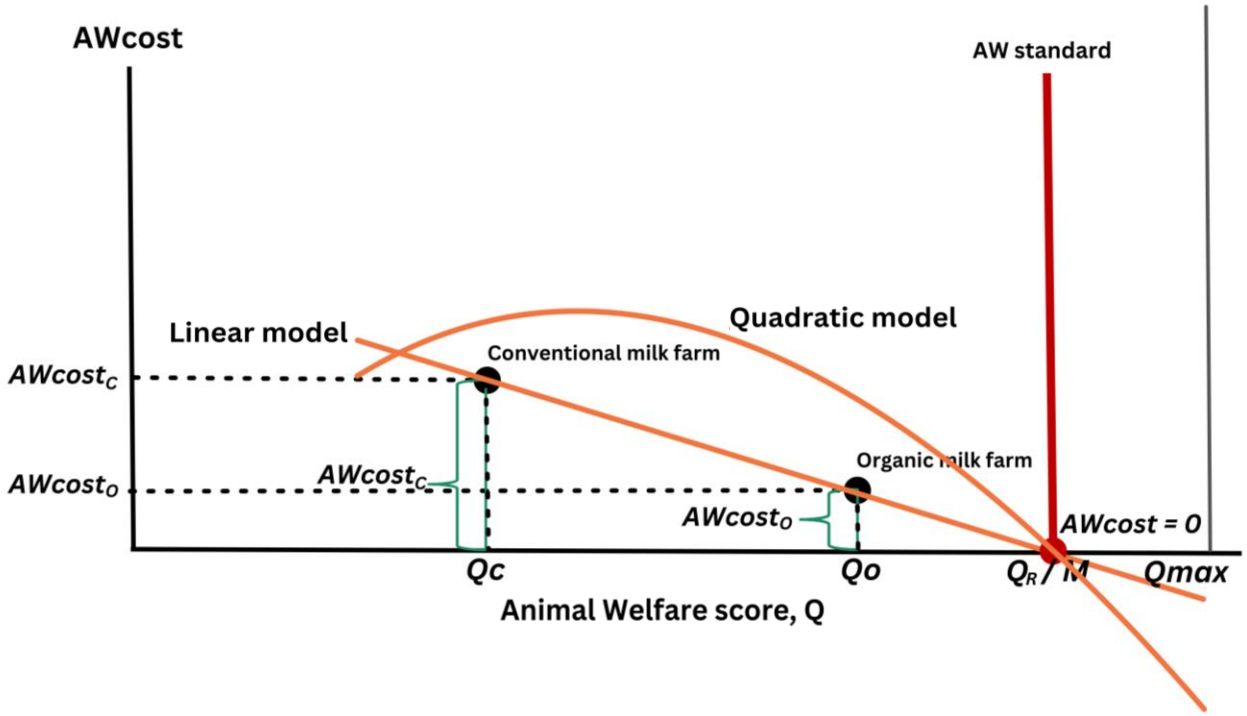


*Include potential benefits; Animal welfare (AW); Energy-corrected milk (ECM).

Scan here for Visser et al., 2023

Scan here for Compliance costs for AW standards

Illustration of the cost-function for AW score and AW cost



AW Assessment

Sub-indicator scoring caps are weighted based on how they affect the animal's health and well-being.

Resource-based indicators

Number of working drinkers (2)

Waterflow rate (4)

Cleanliness (4)

Lying space usage (10)

Scan here for AW Protocols and scales

Animal-based indicators

BCS (10)

Body cleanliness (10)

Skin alterations (10)

Avoidance distance (10)

Status of the claws (10)

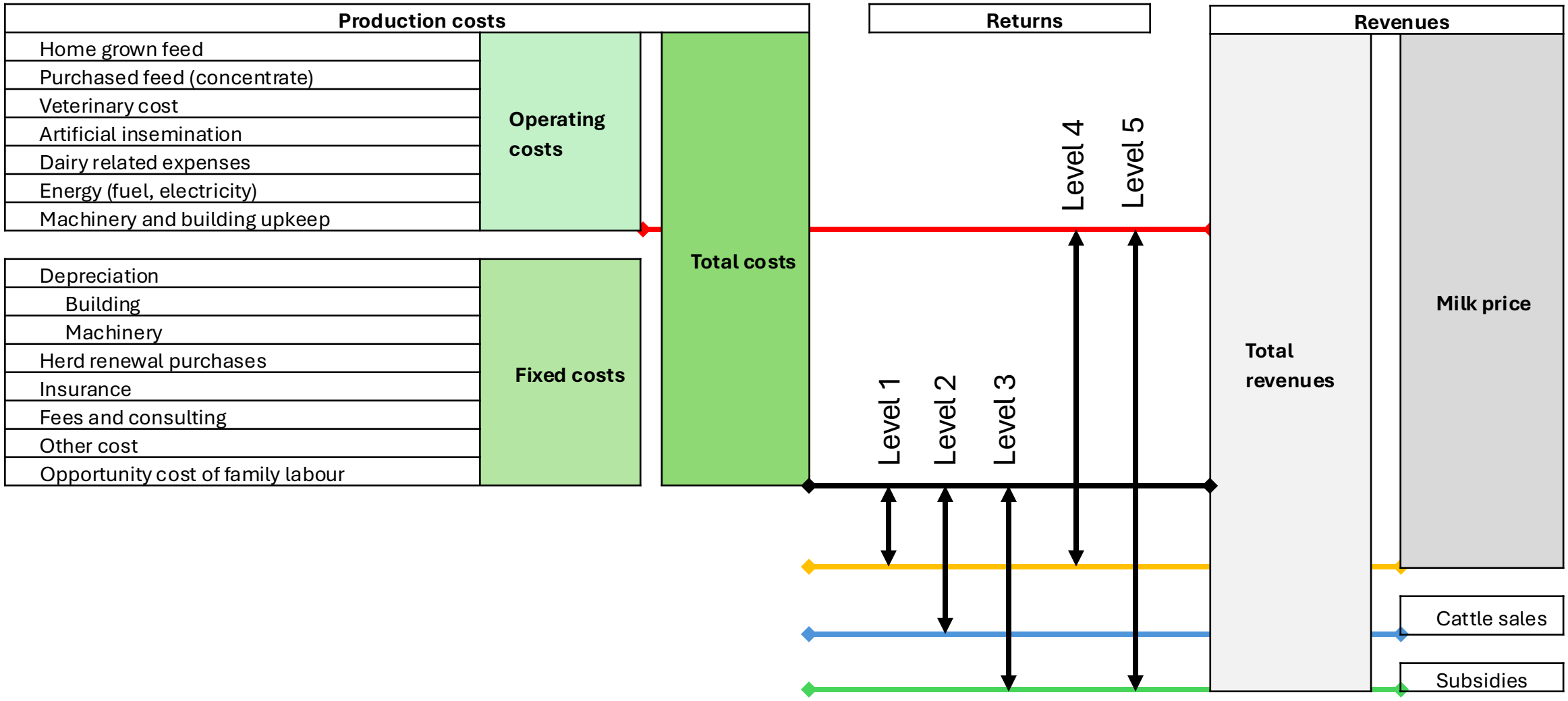
Locomotion (10)

Dystocia occurance (10)

*Numbers in parentheses show the maximum score for each indicator, while each indicator has several sub-indicators.

Milk cost calculation

Milk cost-revenue model



Compliance costs

AW cost formula = Compliance costs (Net cost & benefit) minus Initial condition costs.

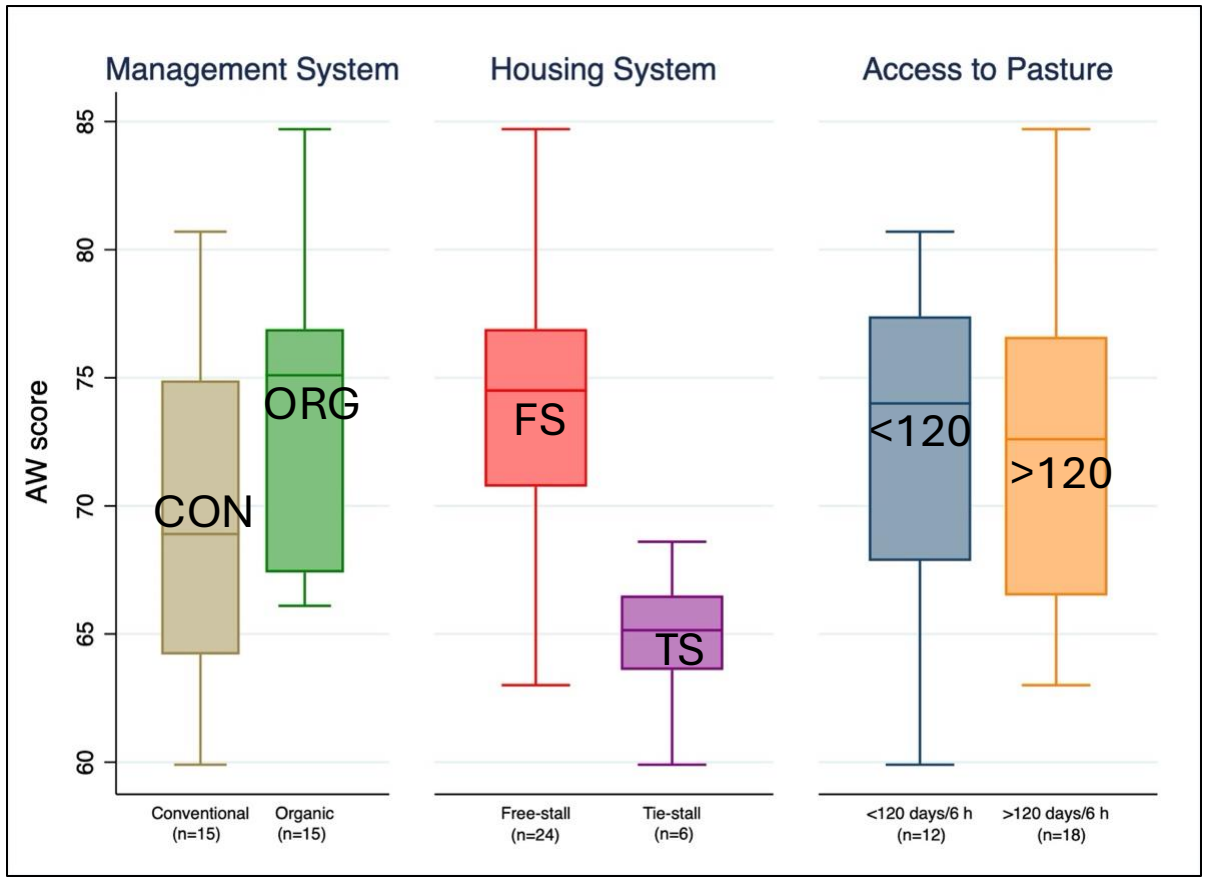
Criteria for AW standard scenarios for estimating compliance costs.

Criterion		
Resource-based indicators		
Housing	○	**Free stall housing** or tethering with the possibility of movement
Space requirements	○	6 m^2 covered, usable floor area per cow
	○	Exception for covered stall systems with covered lying boxes/feeding places, such as cubicle systems
	○	**Animal-to-lying** space ratio: 1:1
	○	Animal-to-feeding space ratio: 1.5:1
	○	Width of free passages with drinkers/brushes: at least 3.0 m
	○	Aisle width at the feeding table: at least 3.0 m
	○	Aisle width at the lying boxes: at least 2.5 m
	○	Dead-ends aisles < 3.0 m width, up to 6 lying boxes allowed
	○	Max. 10% of lying places in dead-end aisles
Functional areas	○	**Bedding mattress** ≥ 5cm
	○	Walking and feeding areas with solid or perforated flooring (non-slip, safe for walking)
Selection Criteria	○	Lying box width: 1.20 m
	○	At least one cow brush or adequate scrubbing device per 60 animals
Management-based indicators		
Grazing access	•	**Grazing access** (120 days/6 h)
On-farm Self-Assessment	•	Farm self-control according to KTBL animal welfare indicators
Animal health	•	Documented routine hoof care twice a year
	•	Selective antibiotic according to regulation
Further training for animal caregivers	•	Participation in training courses

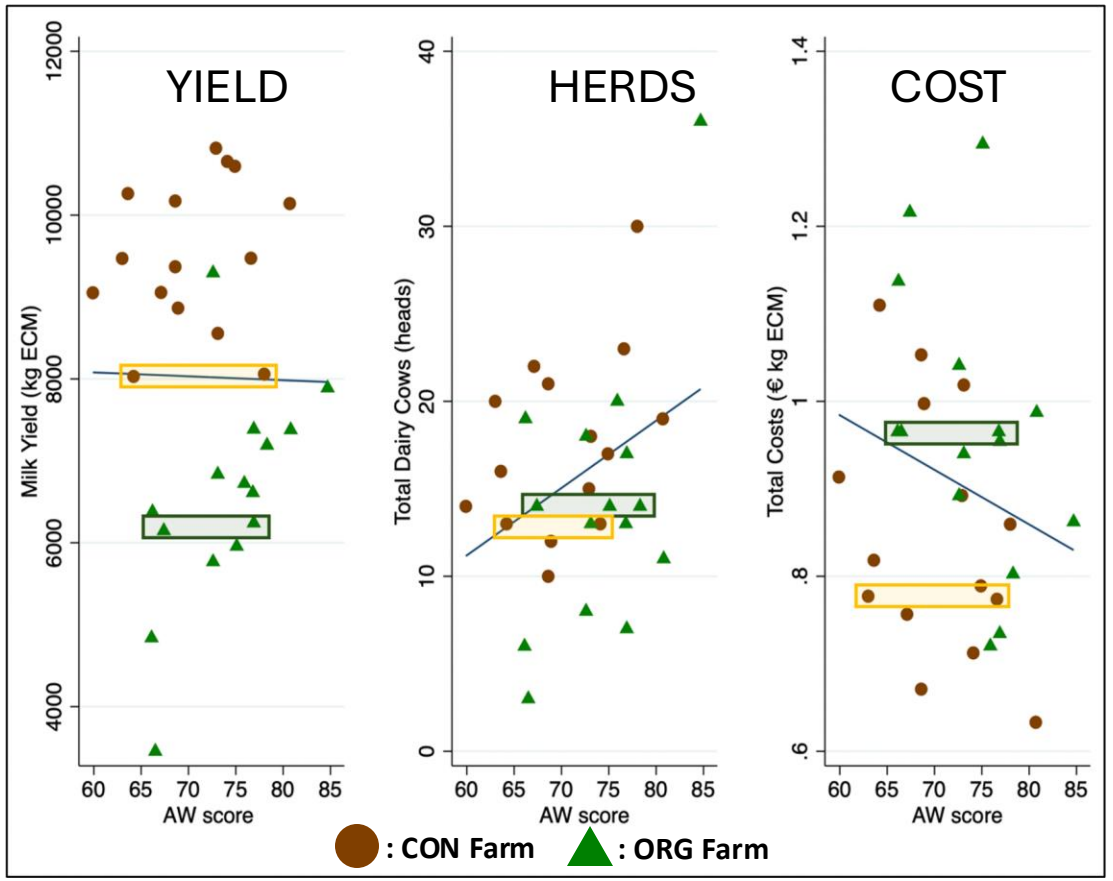
Result

Structural and management drive wide fluctuations in AW scores, even across similarly performing farms.

AW score across different system



AW score across farm performance



Result

Why the quadratic model fits best?

Higher R^2 and significant variables prove a non-linear cost relationship.

Estimating AW costs (€/kg ECM) for achieving AW standards

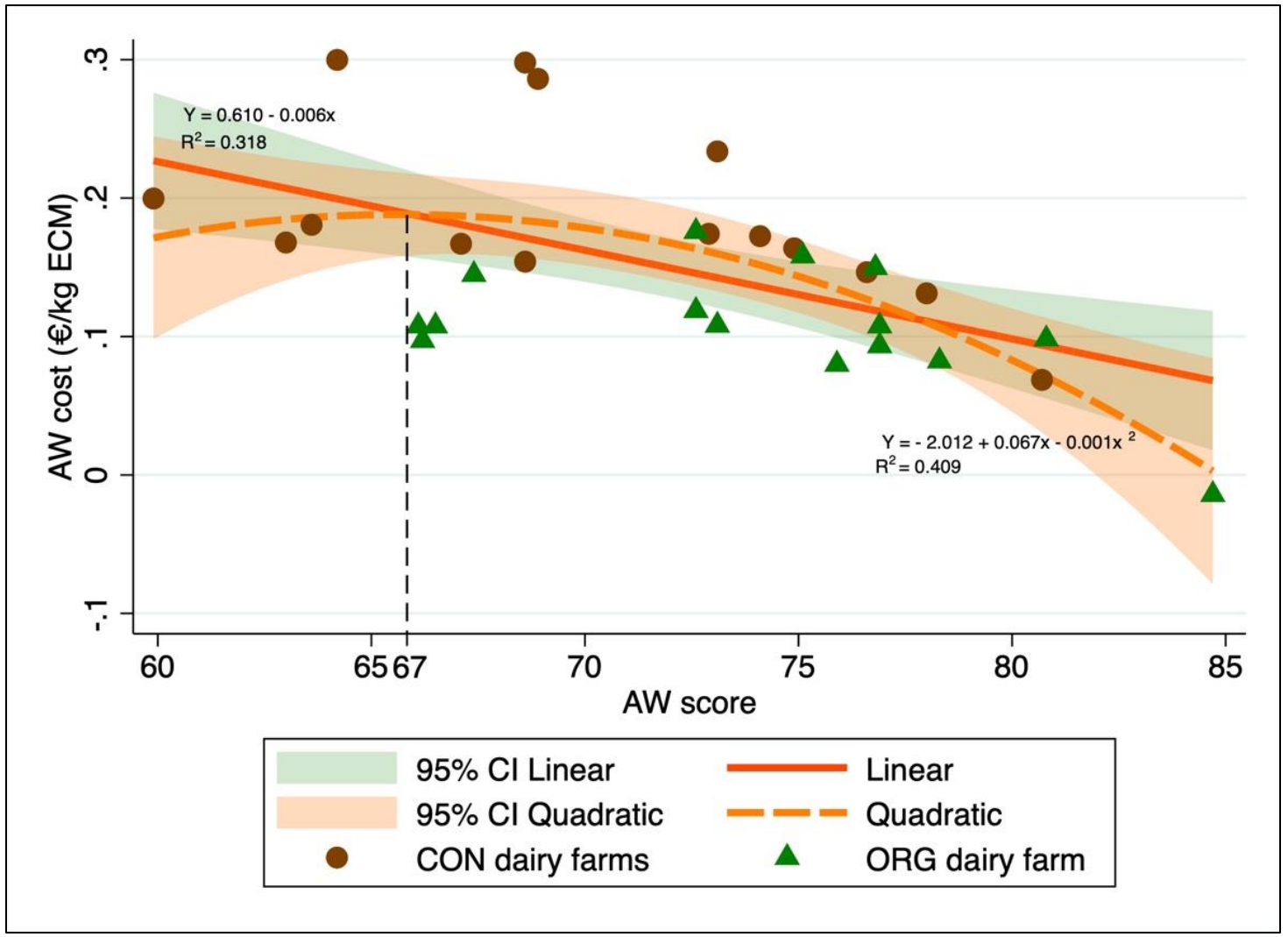
Variable	Linear			Quadratic		
	Estimate (β)	S.E.	P-value	Estimate (β)	S.E.	P-value
AW score	-0.002	0.001	0.122	-0.002	0.001	**0.024**
AW score_square				-0.0003	0.0001	**0.018**
Management system (1: ORG, 0:CON)	-0.058	0.024	**0.027**	-0.046	0.023	**0.055**
Herd size (total of cows; LU)	-0.004	0.0008	**<0.000**	-0.002	0.001	**0.002**
Working time (h/LU/year)	-0.0001	0.0001	**0.032**	-0.0002	0.0001	**0.037**
Pastureland (ha)	-0.033	0.012	**0.014**	-0.037	0.011	**0.003**
Total cost (€/kg ECM/year)	0.207	0.039	**0.000**	0.203	0.035	**<0.000**
Intercept	0.246	0.095	**0.017**	0.291	0.087	**0.003**
N	30			30		
F-statistic	24.13			26.52		
F-value	<0.0000			<0.0000		
R^2	0.8629			0.8941		
Adjusted R^2	0.8271			0.8604		
The Breusch–Pagan test (P-value chi2)	0.7429			0.9084		
The Shapiro-Wilk test to residuals (P-value z)	0.88963			0.5256		

Bold value indicates significant different at 5%.

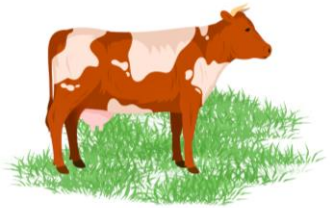
Result

"Quadratic" reflect an initial financial burden for elevating AW standards that diminishes upon reaching target standards.

Cost function (Linear vs. Quadratic)

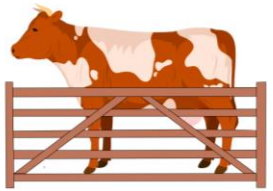


Statistically, achieving the AW standard scenario in this case study requires an estimated additional cost of:



ORG Farms

6 €cents per kg ECM



CON Farms

11 €cents per kg ECM

Key takeaways and future directions

Let's connect!

- **Strategic Indicator Weighting:** Evolve from equally-weighted scales to ratio scales. Weights must reflect both biological severity and economic impact to prevent artificial compensation across indicators.
- **Benchmark-Driven Subsidies:** Tie AW scores to specific market standards (e.g., haltungsform/QM+) so policy subsidies accurately offset true farm-level compliance costs.
- **Interdisciplinary Collaboration:** Accurate economic modeling requires deep collaboration between welfare scientists and economists to address the complex cost implications of specific animal-based indicators.
- **Foundational Proof-of-Concept:** Despite sample size (*N=30*) and regional constraints, this methodology provides foundational framework for evaluating the true investment of AW policy incentives.